



**US Army Corps
of Engineers**®
Galveston District

Greens Bayou Houston, Texas Flood Damage Reduction

Draft General Reevaluation Report and Environmental Assessment



U.S. Army Corps of Engineers
Southwestern Division
April 2005

**Greens Bayou
Houston, Texas
Flood Damage Reduction
DRAFT
General Reevaluation Report and Draft Environmental Assessment**

The responsible lead Federal agency for this study is the U.S. Army Corps of Engineers (USACE), Galveston District, Texas. The non-Federal sponsor for the study is the Harris County Flood Control District (HCFCD), which is acting on behalf of the Harris County Commissioner's Court. This report is a combined General Reevaluation Report and Environmental Assessment complying with requirements of the USACE and the Council of Environmental Quality, and is intended to reduce duplication and paperwork. An asterisk in the table of contents notes paragraphs that are required for National Environmental Policy Act (NEPA) compliance.

Recommended Plan

The Recommended Plan for Greens Bayou includes channel improvements and a detention basin for a flood damage reduction project. (See Exhibit 1 for project location map) The Recommended Plan will reduce flood stages by approximately 2.6 feet at Veterans Memorial and 3.8 feet at Cutten Road for a storm expected to occur once every 10 years and approximately 0.6 feet and 2 feet respectively for a storm expected to occur once every 100 years (see the following Water Surface Reduction Table). With the Recommended Plan in place, an estimated 548 structures and 1,600 persons would no longer be susceptible to the damaging effects of a storm expected to occur once in 100 years. The floodplain would be removed from an estimated 392 structures for a storm expected to occur once in 10 years.

Water Surface Reduction Table

Location	10 Year Storm	100 Year Storm
US 59 to I-45	0.0-0.5	0.0-0.5
I-45 to Greens Parkway	0.5-1.5	0.0-0.5
Greens Parkway to Veterans Memorial	2.0-2.5	0.0-0.5
Veterans Memorial to West Greens	2.5-3.5	0.5-1.0
West Greens to Bammel N. Houston	3.0-4.0	0.5-1.0
Bammel N. Houston to Cutten	2.5-4.0	1.0-2.5
Cutten to SH 249	0.5-2.0	0.0-1.0

The channel improvements consist of a varying top width from 150 to 180 feet with a 60-foot bottom width channel from Cutten Road downstream to Veterans Memorial (3.7 miles). The channel will have 3:1 side slopes, except for the 4:1 side slopes from Bammel N. Houston to 2,900 feet downstream of Bammel N. Houston. From approximately Antoine Road upstream to the existing Cutten Road Detention Basin, the channel will have a 12-foot aesthetic flood bench, four to six feet above the channel flow line on either the north or south channel bank. The channel improvements will require no bridge modifications, but eight utility adjustments will be needed. See Exhibit 2 for the typical channel cross-sections.

The second feature of the Recommended Plan is construction of a new 108-acre stormwater detention basin in the vicinity of West Greens Road on a 138-acre site owned by the HCFCD. (see Exhibits 3, 4 and 5). The storage volume of the detention basin will be approximately 1,650 acre-feet. The basin site consists of 30 acres on the immediate south overbank of Greens Bayou and 78 acres further south and across West Greens Road. Four 10- by 10-foot concrete box culverts under West Greens Road will connect the two compartments of the basin. Inflow to the basin will be by an overflow channel weir on the side-slope of the Greens Bayou channel. The weir design allows the low flow to bypass the detention basin while reserving the basin storage volume for flood events when it is needed. The weir will be approximately 260 feet long, and its crest will be about 4 feet above the proposed channel flowline. When the detention basin stages recede below the weir crest, drainage will be by means of three, one-way three-foot diameter reinforced concrete pipes. The existing Cutten Road Detention Basin weir will be modified slightly as part of the project design.

The Recommended Plan was developed to be environmentally sensitive to the existing natural environment. The channel features include a meandering low-flow pilot channel, planting of native trees along the project right-of-way (ROW), and establishment of turf on channel side-slopes and berms. The detention basin will include planting of native trees, shrubs and grasses, and establishment of wetland plantings in the basin as an environmental feature . About 800 trees would be planted along both sides of the channel ROW and about 500 trees would be planted on the 12-foot flood bench. Proposed species to be planted include pecan, live oak, loblolly pine, black gum, green ash, and bald cypress, but not necessarily limited to these species. Some alignment modifications will be made to preserve existing mature native trees along the channel ROW. The perimeter of the basin will be graded to emulate a natural landscape and environmental preservation techniques will be used to preserve stands of mature existing trees and native shrubs. About 2,650 native trees and 1,060 native shrubs are proposed for planting in the proposed detention basin. Species proposed for planting in the basin include bald cypress, water oak, green ash, red maple, and sycamore, but are not necessarily limited to these species.

Although the Recommended Plan does not include recreation facilities, it will allow for future recreation development.

The project is estimated to have an initial cost of \$37.8 million and fully funded cost of \$40.4 million. The Federal share is estimated to be \$28.3 million. The HCFCD share is estimated to be \$9.5 million, which includes monies HCFCD has already expended purchasing the detention basin site. The project is estimated to have a construction period of four years. The Recommended Plan maximizes the average annual national net excess economic benefits. This maximization of the Federal investment will provide approximately \$10.8 million in annualized benefits with an annualized project cost of approximately \$2.7 million. The resultant benefit-to-cost ratio is approximately 4.0. See the following tables for with and without- project amounts and benefits comparison:

Sum of Structures Value (entire main stem)	10-Year	25-Year	100-Year
Without-Project	\$71,967,000	\$155,258,000	\$239,053,000
With Project	\$43,692,000	\$ 95,739,000	\$181,955,000
Reduction in Value	\$28,275,000	\$ 59,519,000	\$ 57,098,000
Number of Structures (entire main stem)	10-Year	25-Year	100-Year
Without-Project Damages	824	1810	2744
With Project Damages	432	1025	2196
Structures No Longer Vulnerable	392	785	548

Sum of Structures Value (project reach only)	10-Year	25-Year	100-Year
Without-Project Damages	\$11,602,000	\$33,015,000	\$61,263,000
With Project Damages	\$ 425,000	\$ 6,965,000	\$23,012,000
Reduction in Damages	\$11,177,000	\$26,050,000	\$38,251,000

THE OFFICIAL CLOSING DATE FOR THE RECEIPT OF COMMENTS IS 30 DAYS FROM THE DATE ON THE NOTICE OF AVAILABILITY FOR THE GENERAL REEVALUATION/ENVIRONMENTAL ASSESSMENT.

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Exhibit 2



Figure 3 – Proposed Detention Basin

Exhibit 5

**Greens Bayou
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General Reevaluation Report and Draft Environmental Assessment**

TABLE OF CONTENTS

EXECUTIVE SUMMARY.....	1
SUMMARY INTRODUCTION	
MAJOR CONCLUSIONS AND FINDINGS	
1.0 STUDY INFORMATION.....	7
1.1 STUDY AUTHORITY	
1.2 DESCRIPTION OF AUTHORIZED PROJECT	
1.3 PURPOSE AND SCOPE	
1.4 LOCATION OF THE STUDY AREA	
1.5 HISTORY OF THE INVESTIGATION	
1.6 NON-FEDERAL SPONSOR AND COORDINATION	
1.7 PRIOR REPORTS AND EXISTING PROJECTS	
1.8 PLANNING PROCESS AND REPORT ORGANIZATION	
2.0 PROBLEM IDENTIFICATION.....	15
2.1 FLOODING PROBLEMS	
2.2 PUBLIC CONCERNS	
2.3 WATER QUALITY NEEDS	
2.4 SOCIAL AND ECONOMIC NEEDS	
2.5 NATURAL AND ENVIRONMENTAL NEEDS	
3.0 FORMULATION OBJECTIVES, CONSTRAINTS AND CRITERIA.....	20
3.1 NATIONAL OBJECTIVES	
3.2 PLANNING OBJECTIVES	
3.3 PLANNING CONSTRAINTS	
3.4 FORMULATION AND EVALUATION CRITERIA	
4.0 PLAN FORMULATION.....	25
4.1 PLAN FORMULATION RATIONALE	
4.2 INITIAL PLAN FORMULATION	
4.3 REFINEMENT OF HYDROLOGY	
4.4 PLAN FORMULATION (SECOND SCREENING)	
4.5 COMPARISON OF ALTERNATIVES	
4.6 DESCRIPTION OF THE RECOMMENDED PLAN	

4.7	COMPARISON OF AUTHORIZED AND RECOMMENDED PLANS	
4.8	IMPLEMENTATION REQUIREMENTS	
5.0	AFFECTED ENVIRONMENT*	55
5.1	GENERAL DESCRIPTION	
5.2	BIOLOGICAL RESOURCES	
5.3	THREATENED AND ENDANGERED SPECIES	
5.4	WATER QUALITY	
5.5	HISTORIC PROPERTIES	
5.6	HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW)	
5.7	AIR AND NOISE QUALITY	
5.8	RECREATION RESOURCES	
5.9	PRIME AND UNIQUE FARMLANDS	
5.10	SOCIOECONOMIC RESOURCES	
5.11	ENVIRONMENTAL JUSTICE	
5.12	LAND USE	
5.13	GEOLOGY AND SOILS	
6.0	ENVIRONMENTAL CONSEQUENCES*	72
6.1	IMPACTS ON BIOLOGICAL RESOURCES	
6.2	IMPACTS ON THREATENED AND ENDANGERED SPECIES	
6.3	IMPACTS ON WATER QUALITY	
6.4	IMPACTS ON HISTORIC PROPERTIES	
6.5	IMPACTS ON HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW)	
6.6	IMPACTS ON AIR AND NOISE QUALITY	
6.7	IMPACTS ON RECREATION	
6.8	IMPACTS ON PRIME AND UNIQUE FARMLANDS	
6.9	IMPACTS ON SOCIOECONOMIC IMPACTS	
6.10	ENVIRONMENTAL JUSTICE	
6.11	IMPACTS ON LAND USE	
6.12	IMPACTS ON GEOLOGY AND SOILS	
6.13	MITIGATION	
7.0	CUMULATIVE IMPACTS AND OTHER RELATED ANALYSES*	83
8.0	PUBLIC INVOLVEMENT, REVIEW AND CONSULTATION*	89
8.1	PUBLIC INVOLVEMENT PROGRAM	
8.2	INSTITUTIONAL INVOLVEMENT	
8.3	ADDITIONAL REQUIRED COORDINATION	
8.4	REPORT RECIPIENTS	
8.5	PUBLIC VIEWS AND RESPONSES	
9.0	RECOMMENDATIONS	93
10.0	LIST OF REFERENCES	98

LIST OF TABLES

Table 1 – Net Excess Benefits	3
Table 2 – Economic Summary of Recommended Plan	5
Table 3 – Comparison of Estimated Emissions (tons/year) to General Conformity Thresholds	6
Table 4 – Average Annual Cost & Benefits of Authorized Plan	8
Table 5 – Levee Plans – Planning Reach #1	29
Table 6 – Screening Plans – Planning Reach #2	30
Table 7 – Screening Plans – Planning Reach #3	31
Table 8 – Screening Plans – Planning Reach #4	31
Table 9 – Benefit-to-Cost Ratio	32
Table 10 – Initial Screening Alternatives	33
Table 11 – Average Annual Equivalent Damages to Structures and their Contents	35
Table 12 – Channel Optimization with Mitigating Detention Between Veteran’s Memorial and Cutten Road	39
Table 13 – Optimization of Detention Basin w/60-foot Channel	40
Table 14 – Nonstructural Buyout of Floodplains	43
Table 15 – Nonstructural Bayou Section 219 Compliant	44
Table 16 – Alternative Plans	45
Table 17 – Distribution of FEMA-Purchased Structures by Floodplain, Post Tropical Storm Allison, June 2001	46
Table 18 – Economic Summary of Recommended Plan	51
Table 19 – Comparison of Authorized Project and Recommended Plan (Flood Control)	52
Table 20 – Construction Schedule	53
Table 21 – Project Cost	54
Table 22 – Federally Listed Threatened or Endangered Species	60
Table 23 – Texas Parks and Wildlife Department, Texas Annotated County List Of Rare Species for Harris County	60
Table 24 – Land Use – Existing 1 Percent Annual Exceedance Floodplain of Greens Bayou	70
Table 25 – Computed Decreases in Water Surface Elevation Above Confluence With Garner’s Bayou to Mouth	73
Table 26 – Comparison of Estimated Emissions (tons/year) to General Conformity Thresholds	
Table 27 – Project Costs	94

LIST OF FIGURES

Figure 1 – Plan of Improvement	9
Figure 2 – 0.2% Annual Exceedance Floodplain	12
Figure 3 – Planning Reaches Defined for Initial Screening	28
Figure 4 – Detention Basin	42
Figure 5 – Recommended Plan	48
Figure 6 – Cross Sections of Proposed Channel Improvements	49
Figure 7 – Detention Basin Vegetation Classification	57
Figure 8 – Placement Sites	59

APPENDIX A -- CLEAN WATER ACT SECTION 404(B)(1) EVALUATION

APPENDIX B -- COORDINATION WITH OTHERS

APPENDIX C -- HEP EVALUATION AND CE/ICA FOR PROJECT MITIGATION

**Greens Bayou
Houston, Texas
Flood Damage Reduction
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General Reevaluation Report and Environmental Assessment**

EXECUTIVE SUMMARY

SUMMARY INTRODUCTION

This report is in response to the study authorization contained in PL 101-640, Section 101(a)(21), dated November 28, 1990, of the Water Resources Development Act of 1990 (WRDA 1990). The report presents the results of studies for reducing flood damages within the Greens Bayou watershed. The Greens Bayou project was developed as part of the comprehensive flood control plan for Buffalo Bayou and Tributaries. The May 1988 Feasibility Report for the Buffalo Bayou Comprehensive Study underwent Washington-level review and was approved by the Board of Engineers for Rivers and Harbors on June 13, 1989. The authorized project for Greens Bayou extends the entire length of the bayou and includes 14 miles of stream clearing, 25.2 miles of channel enlargement, and four detention basins (Figure 1 of Main Report). The authorized project also includes recreation features as well as environmental features.

Greens Bayou is located in north central Harris County, about 10 miles north of the central business district of the City of Houston, Texas. The Greens Bayou watershed drains an area of about 210 square miles. The Cypress Creek and San Jacinto River watersheds adjoin the Greens Bayou watershed to the north and Carpenters Bayou adjoins the bayou to the east. The bayou flows across northern Harris County generally eastward from its headwaters near Farm-to-Market (FM) 1960 for about 23 miles, and then turns at its confluence with Garners Bayou and flows southward for about 19 miles to its outfall into the Houston Ship Channel (Buffalo Bayou). The Harris County Flood Control District (HCFCD) has made channel improvements upstream of U.S. Highway 90. The bayou contains an existing federally constructed navigation channel in the lowermost three miles. The study area is the 0.2 percent annual exceedance probability floodplain of the entire stream and is shown in the accompanying drawing (Figure 2).

This General Reevaluation Report (GRR) presents the results of the reevaluation study and describes the study activities that have occurred since project authorization in 1990. In May 1994, the HCFCD requested an investigation be conducted on the flooding problems on Greens Bayou.

MAJOR CONCLUSIONS AND FINDINGS

Planning Objectives

The investigation of the problems and opportunities in the study area led to the establishment of the following planning objectives:

- ♦ Construct the most cost-effective and technically sound urban flood damage reduction project for the Greens Bayou watershed
- ♦ Contribute to environmental quality by enhancing the area with environmental quality features and avoiding fish and wildlife habitat.

Alternatives

A wide range of alternatives was formulated to address the planning objectives. Initially, 21 structural, non-structural and various combinations of plans were evaluated. Structural buyouts, levees, channel improvements, and raising structures were considered. Plans were eliminated that were not economically feasible and/or did not meet requirements. The results of initial screening produced the plan named CUT-CHD3 with the greatest net excess benefits and produced a benefit-to-cost ratio (BCR) greater than unity. This plan consisted of an earthen channel, 55 feet wide, extending from the bridge at Greens Parkway to the bridge at Cutten Road, with a downstream mitigating detention basin. The channel was designated the anchor component and was optimized to 60-foot bottom width.

Mitigation for induced increases in water surface elevations had been prematurely applied to the optimized structural channel segment since opportunities for further flood damage reduction had not yet been exhausted. This realization spurred optimization of what had once functioned as the mitigating detention basin. Therefore, the detention basin was optimized to 108 acres as a flood damage reduction feature.

As a result of plan formulation, four complete plans were developed as flood damage reduction solutions. These plans included: 1) a 60-foot bottom width trapezoidal channel with mitigating detention; 2) a 60-foot bottom width channel with a 108-acre detention basin; 3) a stand-alone nonstructural evacuation/buyout; and 4) a combination plan - a 60-foot bottom width channel/108-acre detention basin with residual evacuation/buyout. Plan 2 is considered to be the most cost effective and maximizes net excess benefits over costs (see Table 1).

Identification of the NED Plan

The Federal objective in water resources planning is to contribute to the national economic development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders and other planning requirements. Accordingly, it was found that the 60-foot channel with the 108-acre basin/weir configuration 2 best currently meets the NED objective. This plan is the Recommended Plan. This plan is selected for implementation.

TABLE 1***				
Net Excess Benefits				
Alternative Plan	Damages Reduced AAE**	AAE** Cost	Net Excess Benefits (AAE**)	BCR
Structural				
<i>1 - 60-Foot Channel</i>	\$2,403	\$1,228	\$1,175	2.0
<i>2 - 60-Foot Channel w/108-Acre Basin/Weir 2</i>	<i>\$5,203</i>	<i>\$1,391</i>	<i>\$3,812</i>	<i>3.7</i>
Non-Structural				
<i>3 - 20% AEF* Residential & Non- Residential</i>	\$5,593	\$4,257	\$1,336	1.3
Structural/Non-Structural				
<i>4 - 60-Foot Channel w/ 108-Acre Basin/Weir 2 w/Residual Buyout of 50% AEF*</i>	\$5,328	\$1,528	\$3,800	3.5

2001 price level and 5.625% interest rate, in thousand dollars

* Annual Exceedance Floodplain

**Average Annual Equivalent

***Damages to Structures and Contents Only

Features of the Recommended Plan

The proposed project includes two features. The first is reconstructing and recontouring a portion of the Greens Bayou channel between Cutten Road and Veteran's Memorial Drive. The channel improvements consist of a 60-foot bottom width trapezoidal channel with a meandering low flow pilot channel one foot below the channel bottom. From approximately Antoine Road upstream to the existing Cutten Road Detention Basin, the channel will have a 12-foot bench, four to six feet above the channel bottom, on either the north or south channel bank. Trees will be preserved wherever possible.

The second feature of the proposed project is the construction of a 108-acre stormwater detention basin on a 138-acre site, in the vicinity of West Greens Road, owned by the HCFCF. The basin will be bound generally by Antoine Road, the Sam Houston Tollway, by the Briarcreek Subdivision and Greens Bayou. West Greens Drive will bisect the basin, dividing it into two

parts, but it will function as a single flood damage reduction feature. The basin site consists of 30 acres on the immediate south overbank of Greens Bayou and 78 acres further south and across West Greens Road. Four 10- by 10-foot concrete box culverts under West Greens Road will connect the two compartments of the basin. Inflow to the basin will be by an overflow side-channel weir on the side-slope of the Greens Bayou channel. The weir will be approximately 260 feet long and will have an elevation of about 106 to 108 feet. The side-channel weir allows the basin storage stages to recede closely with Greens Bayou flood stages. However, for the detention basin to drain when basin stages have receded below the weir crest, drainage will be by means of three, one-way three-foot diameter reinforced concrete pipes. This allows the basin to recover its storage capacity as quickly as possible after flooding on Greens Bayou. Trees and wildlife habitat will be preserved wherever possible.

The proposed project integrated environmental quality features with project flood damage reduction features. The project design includes environmental features for the channel and the detention basin. The environmental quality features in the channel consist of a meandering low-flow pilot channel, preserving or planting native trees along the project right-of-way (ROW), and establish turf on channel side slopes and berms. The detention basin will include plantings of native trees, shrubs and grasses, establishment of wetland plantings in the basin, and the opportunity for development of a perimeter-walking trail in the basin. These features are designed to improve the aesthetic and visual attractiveness of the project, as well as provide environmental quality.

Benefits and Costs of the Recommended Plan

The Recommended Plan would provide project benefits in the form of reduction of damages to structures and content, roads, utilities, vehicles and reduced emergency costs. Table 2 shows a breakdown of first and annual costs and benefits of the recommended plan, along with the net economic benefits and BCR.

Local Support

The HCFCD has expressed the desire for implementing the Recommended Plan and sponsoring project construction in accordance with the items of local cooperation that are set forth in this report. The financial analysis indicates that the Non-Federal Sponsor is financially capable of participating in the Recommended Plan.

Findings Regarding Section 404(b), Clean Water Act (CWA), as amended.

Section 404 of the CWA regulates the discharge of dredged or fill material into waters of the United States. A Section 404(b)(1) evaluation of the proposed activity was prepared and is included in Appendix B. A Section 401 State Water Quality Certification for this action will be obtained to comply with the Act. The proposed plan will include Section 402(p) requirements of the CWA where applicable.

Table 2		
Economic Summary of Recommended Plan		
Benefit Category	Average Annual Benefits	Average Annual Benefits
Structures & Contents	\$ 5,203,000	\$ 5,536,000
Roads	\$ 961,000	\$ 1,019,000
Utilities	\$ 113,000	\$ 120,000
Vehicles	\$ 3,636,000	\$ 3,854,000
Other Costs	\$ 213,000	\$ 226,000
Total AAE* NED Benefits	\$10,126,000	\$10,755,000
Cost Category	Cost	Cost
PED	\$ 5,470,000	\$ 5,470,000
Lands and Damages	\$ 5,521,000	\$ 5,589,000
Construction	\$20,910,000	\$21,943,000
Const. Contingency	\$ 4,587,000	\$ 4,776,000
Operation/Maintenance	\$ 4,810,000	\$ 4,710,000
Interest During Construction	\$ 3,885,000	\$ 3,814,000
Total NED Cost	\$45,183,000	\$46,302,000
AAE Total NED Cost	\$ 2,718,000	\$ 2,685,000
AAE Net Excess Benefits	\$ 7,408,000	\$ 8,070,000
BCR	3.73	4.01
Price Level – Interest Rate	Oct 2001 – 5-5/8%	Oct 2004 – 5-3/8%

**Average Annual Equivalent (AAE)*

Findings Regarding Section 7, Endangered Species Act

The USFWS was contacted regarding endangered, threatened or proposed species and their critical habitats potentially found in the project area. Available information and investigations have determined that the proposed project plan will not result in adverse impacts to any federally listed threatened or endangered species. The USFWS will be requested to concur in this determination.

Findings Regarding the Clean Air Act, as amended

A preliminary analysis of air contaminant emissions for the Greens Bayou Project was done to determine if the construction of the proposed plan would generate nitrogen oxide (NO_x) and volatile organic compound (VOC) emissions (ozone precursors) above de minimus levels specified in the General Conformity rules, as established by the Clean Air Act, for the Houston Galveston Nonattainment Area (HGA) (PBS&J, 2005). Currently, the HGA is classified as a

severe nonattainment area for ozone under the 1-hour National Ambient Air Quality Standard for ozone. However, the U.S. Environmental Protection Agency has recently promulgated an 8-hour ozone standard to replace the 1-hour standard. Based on the 8-hr ozone standard, the HGA will be reclassified to a moderate nonattainment area effective June 15, 2005. Accordingly, for this moderate classification, a General Conformity Analysis would not be required if NO_x or VOC emissions would be below 100 tons per year (tpy) for either NO_x or VOC. The Federal project is scheduled to begin in November 2005. Therefore, de minimus level used are 100 tpy each for NO_x and VOC and a General Conformity analysis is not required for this project.

Table 3

Comparison of Estimated Emissions (tons/year) to General Conformity Thresholds

	VOC					NO _x				
Year	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009
Tons/year	0.86	3.97	0.34	0.15	0.05	12.38	66.37	5.16	1.68	0.77
General Conformity Threshold (tons/year)	100	100	100	100	100	100	100	100	100	100
Exceeds Threshold	No	No	No	No	No	No	No	No	No	No

Findings Regarding Executive Order 11988

An evaluation has been made in accordance with Executive Order (EO) 11988 – Floodplain Management – to determine the effect of the Recommended Plan on the base floodplain. This EO directs Federal agencies to evaluate the potential effects of proposed actions in floodplains. The activities associated with construction of the recommended project must be located in the floodplain to fulfill the project's basic purpose. The proposed activity will not induce increased flooding in developed areas, will not contribute to increased future flood damages, and is not expected to induce a higher rate of development within the floodplain.

Findings Regarding EO 11990

The recommended plan includes mitigation measures to offset the loss of 14.72 acres of wetlands that would be lost as a result of construction of the plan. The 14.72 acres of wetlands identified within the detention basin footprint that will be impacted will be mitigated through the creation of 16.3 acres of wetlands within the floodplain. Of the 16.3 acres of wetland creation, 4.2 acres will be constructed along the pilot channel of Greens Bayou for the length of the project (3.7 miles) while the remaining 12.1 acres will be constructed within the detention basin.

1.0 STUDY INFORMATION

This section provides details on the study authority, purpose and scope of this reevaluation study, study participation, and prior studies performed within the study area. It also lists the steps in the USACE planning process and relates them to the organization of this report.

1.1 STUDY AUTHORITY

The general reevaluation study on flood damage reduction for Greens Bayou is part of the comprehensive flood damage reduction plan for the Buffalo Bayou and Tributaries, Texas watershed authorized by resolution of the House Committee on Public Works on April 20, 1948 (House Document No. 456, 75th Congress). The authorized flood control project on Greens Bayou is documented in the report entitled: *Buffalo Bayou and Tributaries, Texas Feasibility Report, Flood Damage Prevention, May 1988*. A Final Environmental Impact Statement (FEIS) was included in Volume II of the report and described the environmental impacts of the authorized Greens Bayou plan. The FEIS was filed with the Environmental Protection Agency on September 9, 1988 (USACE, 1988).

The Greens Bayou at Houston, Texas, project was authorized by Public Law 101-640 Section 101(a)(21), dated November 28, 1990, of WRDA 1990. This law authorizes construction of six different elements identified to reduce flood damages within the Buffalo Bayou watershed. One of these elements is Greens Bayou, Houston, Texas. The public law reads:

“Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled...Except as provided in this subsection, the following projects for water resources development and conservation and other purposes are authorized to be carried out by the Secretary (Secretary of the Army) substantially in accordance with the plans, and subject to the conditions, recommended in the respective reports designated in this subsection:

(21) BUFFALO BAYOU AND TRIBUTARIES, TEXAS – The project for flood control, Buffalo Bayou and tributaries, Texas: Report of the Chief of Engineers, dated February 12, 1990, at a total cost of \$727,364,000, with an estimated first Federal cost of \$403,359,500 and an estimated first non-Federal cost of \$324,004,500.

1.2 DESCRIPTION OF THE AUTHORIZED PROJECT

The project authorized by Congress included structural and nonstructural measures to minimize the impacts of stream flooding along the mainstream of Greens Bayou. The features of the proposed project included clearing and grubbing, floodplain buyout, stream enlargement, and the construction of flood detention basins. The authorized project would provide protection at about the 4 percent annual exceedance to existing properties affected by bayou overflows. The authorized project would reduce potential flood damages by about 89.3 percent from all frequency flood events.

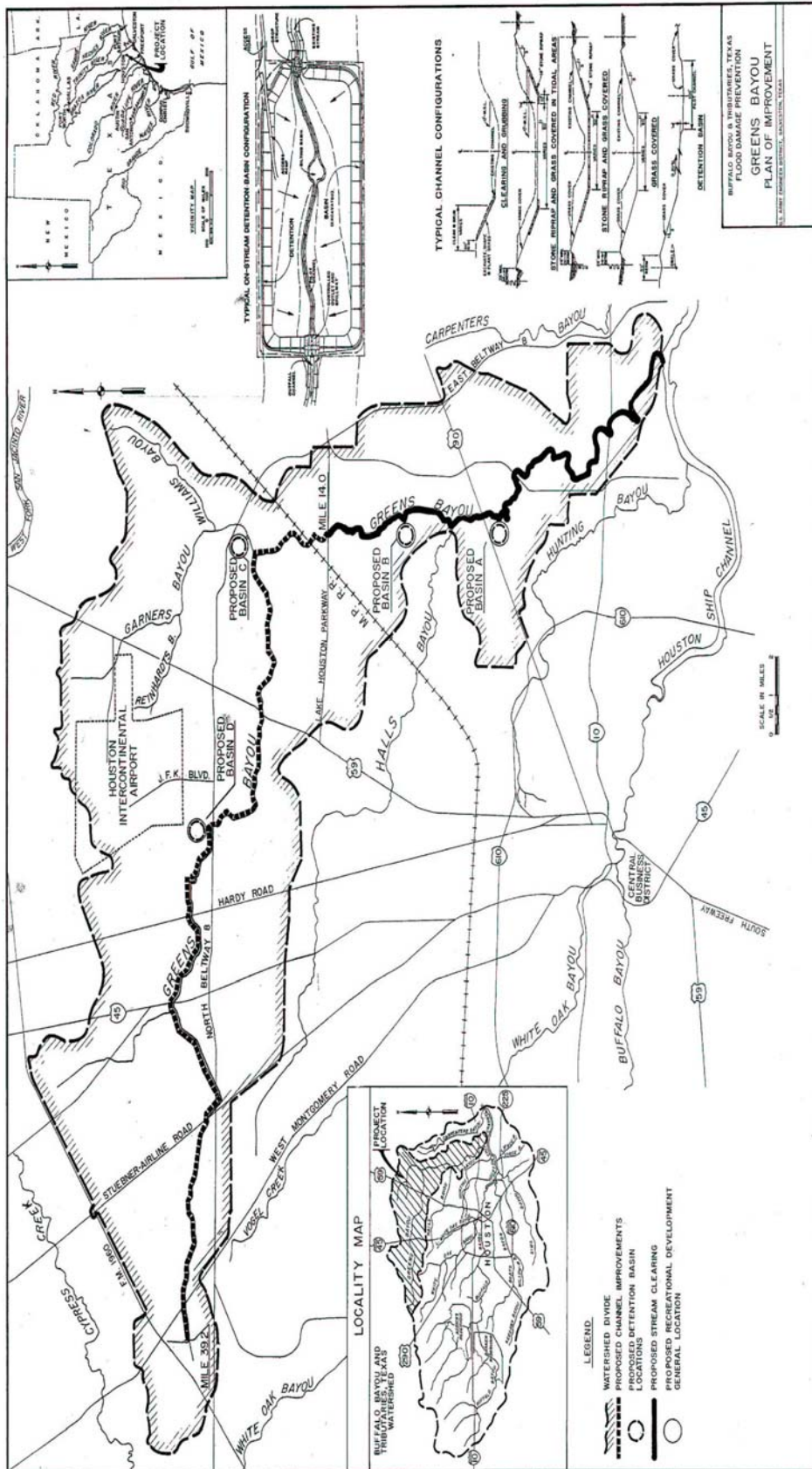
The authorized project on Greens Bayou extends the entire length of the bayou and includes the following:

- ♦ 14 miles of stream clearing and grubbing for the lower reaches of the stream; limited excavation of one bank line of the bayou combined with two off-channel tributary flood detention basins; and buyout of several structures affected by frequent flooding;
- ♦ 25.2 miles of channel improvement and enlargement that would begin near Mount Houston Parkway and extend upstream; stream enlargement would be minimized by the construction on two additional flood detention basins;
- ♦ Environmental features in the form of vegetative screening were added to make the project aesthetically pleasing and compatible with its suburban surroundings; and
- ♦ Recreation features that include trails, picnic tables, a boat ramp, and a small parking lot for adequate public access; and 348 acres suitable for additional recreation facilities.

In Table 4 below, the average annual cost and benefits of the authorized plan are presented.

Table 4				
Average Annual Costs & Benefits of Authorized Plan				
	Authorized Plan	Last Presented to Congress	Authorized Plan Updated	Authorized Plan Update
Benefits	\$34,107,000	\$63,623,000	\$44,534,000	\$45,504,000
Costs	\$12,392,000	\$24,044,000	\$16,830,000	\$17,197,000
Net Excess Benefits	\$21,715,000	\$39,580,000	\$27,704,000	\$28,307,000
BCR	2.7	2.7	2.7	2.7
Price Level	Oct 1988	Oct 2000	Oct 2001	Oct 2004
Interest Rate	8.625%	8.625%	5.625%	5.375%

Note: Data regarding the authorized project is from Buffalo Bayou and Tributaries, Texas Feasibility Report (Flood Damage Prevention), Volume 1 Main Report, May 1988.



1.3 PURPOSE AND SCOPE

This report presents the findings of a reevaluation investigation to reduce flooding problems along Greens Bayou. The focus of the reevaluation is to reformulate a project to reduce flood damages along the mainstream of Greens Bayou in light of current conditions in the watershed, environmental sensitivity, and public acceptance. Changes in the watershed since project authorization include improvements to the channel by the Non-Federal Sponsor for flood damage reduction, identification of damage areas from recent floods, and increased development in the study area. The authorized project is part of the comprehensive analysis of Buffalo Bayou and its tributaries, which included Greens Bayou. This analysis incorporates additional information on recently damaged areas in the study area.

During the study, engineering, economics, and environmental features were analyzed in accordance with current planning policies, criteria, and guidelines. WRDA 1996, Section 575, Harris County, Texas and WRDA 1999, Section 219, Nonstructural Flood Control Projects along with the authorization legislation were used during the planning process. The study resulted in project modifications and changes to the authorized plan to provide for current conditions on Greens Bayou, the Non-Federal Sponsor needs, and the current planning and design criteria. The engineering studies reevaluated structural and non-structural flood damage reduction measures, excavated material placement plans, and project costs. The economic studies analyzed the flood damage reduction benefits with regard to current design criteria. The environmental studies addressed avoidance or minimizing project impacts, any need for mitigation and associated coordination and costs for any mitigation required. Ways to improve environmental and aesthetic qualities of the project were also discussed. In all cases, the studies were developed in sufficient scope to reaffirm project feasibility.

A variety of hydraulic models were required to fully assess existing and future conditions. In addition, hydraulic models were used to measure the effectiveness of proposed damage reduction plans in providing flood protection and the impacts on the environment. Structural and non-structural plans were designed to produce the desired effects recommended in the modeling efforts. Proposed alternatives were evaluated according to the economic and environmental regulations for acceptability under current Federal laws.

This report presents the problems and opportunities and expresses desired outcomes as planning objectives. Alternatives are then developed to address these objectives. Various alternatives, including combinations of structural and non-structural measures, were considered for the authorized project reach. The economic and environmental impacts of the alternatives were then evaluated and a feasible plan was selected. The report also presents details on USACE and Non-Federal Sponsor participation needed to implement the plan. The report concludes with a recommendation for approval.

Studies were conducted to reevaluate the authorized project for Greens Bayou and recommend any changes in the scope of the project consistent with current and future needs. Reevaluation resulted in modifications to the authorized project. The purpose of the environmental assessment was to address modifications to the authorized project based on

results of reevaluation studies. The assessment considered the alternative plans and environmental impacts for the recommended plan.

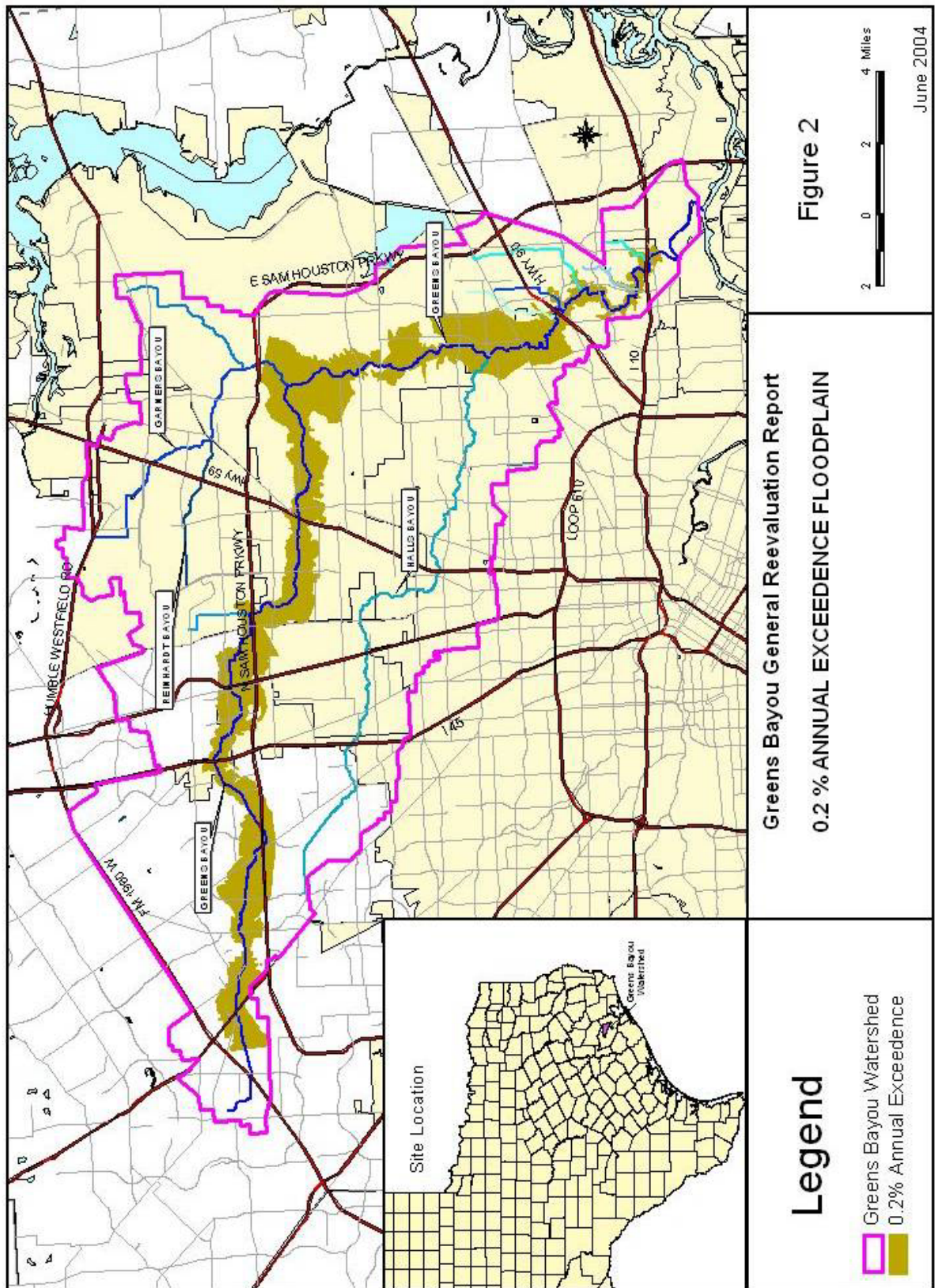
1.4 LOCATION OF THE STUDY AREA

Greens Bayou is located in north central Harris County, about ten miles north of the central business district of the City of Houston, Texas. The Greens Bayou watershed drains an area of about 210 square miles. The Cypress Creek and San Jacinto River watersheds adjoin the Greens Bayou watershed to the north, and Carpenters Bayou adjoins the bayou to the east. The topography of the area is characteristic of the Texas Gulf Coastal Plains - flat, grassy, and mostly treeless. Elevations in this report are referenced to the National Geodetic Vertical Datum (NGVD) with the 1973 subsidence adjustment. The streambed has an average slope of about 3.7 feet per mile. Elevations in the watershed vary from about 123 feet near the headwaters to about 8 feet at the mouth of Greens Bayou. The soils in the region are mostly clay, and excess rainfall tends to run off or pond rather than percolate down through the soil. The geography of the area, rapid development, and high average annual rainfall combine to make the area prone to damaging floods.

The bayou flows across northern Harris County generally eastward from its headwaters near county road FM 1960 for about 23 miles, and then turns at its confluence with Garners Bayou and flows southward for about 19 miles to its outfall into the Houston Ship Channel (Buffalo Bayou). HCFCD made channel conveyance improvements upstream of U.S. Highway 90. The bayou contains an existing federally constructed navigation channel in the lowermost three miles. Upstream of Homestead Road, Greens Bayou is a grass-lined, trapezoidal channel that the HCFCD regularly mows and maintains. From Homestead Road downstream to I-10, the channel is selectively cleared and snagged. From I-10 downstream to the mouth, no maintenance is performed by the HCFCD.

The portion of the stream flowing south from the Garners confluence to the outfall into the Houston Ship Channel is predominantly riparian woodlands and wetlands. From U.S. Highway 90 to just downstream of I-10, the channel has not been improved, and the bayou through this reach approaches its natural state. The major tributaries of the bayou are Garners and Halls Bayou. The study area is the 0.2 percent annual exceedance probability floodplain of the entire stream and is shown on Figure 2.

The study area for economic reanalysis is the Greens Bayou watershed impacted by the estimated median 0.2 percent annual exceedance probability flood event as defined by the most likely future 2055 hydrology. The study area/floodplain is shown on Figure 2



1.5 HISTORY OF THE INVESTIGATION

The Greens Bayou project was developed as part of the comprehensive flood control plan for Buffalo Bayou. In June 1989, a feasibility report on the Buffalo Bayou Comprehensive Study underwent Washington-level review and was approved by the Board of Engineers for Rivers and Harbors. This report included an authorized project on Greens Bayou, which extended the entire length of the bayou and included 14 miles of stream clearing, 25.2 miles of channel enlargement, and four detention basins. Recreation features included trails, picnic facilities, canoe-launching ramps, comfort stations, and parking areas. The flood protection feature, providing approximately 4 percent annual exceedance flood protection, had an estimated first cost of \$121,100,000 at January 1988 price levels. The average annual benefits were estimated at \$32,205,000 for flood damage reduction and \$1,901,800 for recreation. The BCR produced by this project is 2.7 based upon 1988 price levels and 8.625 percent interest rate.

Because the authorized project was large in scope and HCFCD had numerous ongoing projects, they requested a separable element analysis of the Greens Bayou project to improve the feasibility of financing their share of the project cost. In response, USACE conducted an analysis for separable elements. A Limited Reevaluation Report (LRR) for Greens Bayou for Separable Elements was submitted to HQUSACE in October 1993. In March 1994, HQUSACE agreed with the report's findings that separable elements existed; however, phased construction was considered more appropriate. The local sponsor, however, did not support phased construction.

In May 1994, the Non-Federal Sponsor requested that the USACE formulate a project that would focus on the recently damaged areas and had less environmental impacts. The HCFCD expressed that they did not support the proposed plan. Therefore, the authorized plan was not re-modeled for further analysis during the planning process of the GRR study. After a series of partnering meetings, the HCFCD and the USACE initiated the reevaluation study on March 1, 1995 to reformulate a project that addressed environmental issues and recently flood damaged areas.

1.6 NON-FEDERAL SPONSOR AND COORDINATION

The Galveston District was responsible for the overall management of the study and the report preparation. The HCFCD was an integral part of the project delivery team (PDT). They actively participated and contributed during the course of the study since its initiation. The study was coordinated with interested Federal, State, and local agencies and the public. The following are some of the agencies and groups that provided input during the preparation of the report:

Federal Agencies

U.S. Fish and Wildlife Service (USFWS)

U.S. National Marine Fisheries Service (NMFS)

U.S. Environmental Protection Agency

State Agencies

Texas State Historic Preservation Officer (SHPO)
Texas Parks and Wildlife Department (TPWD)
Texas Coastal Management Program (TCMP)
Texas Commission on Environmental Quality (TCEQ)
Texas Department of Health
Texas Railroad Commission

Local Agencies

Harris County Precincts
City of Houston
Harris County Department of Health
Harris County Pollution Control Department

1.7 PRIOR REPORTS AND EXISTING PROJECTS

The following reports were reviewed as directed in the study authorization:

- * Buffalo Bayou and Tributaries, Texas, Feasibility Report (Flood Damage Prevention), May 1988.
- * Greens Bayou at Houston, Texas – Limited Reevaluation Report on Separable Elements Analyses, October 1993.

HCFCF Projects on Greens Bayou include:

- * Excavation of the Cutten Road Basin (P500-02)
- * An active voluntary buyout program in association with the Federal Emergency Management Agency for homes that qualify and have flooded frequently or severely post Tropical Storm Allison.
- * Greens Bayou Regional Flood Control Projects – Channel Conveyance and Detention.
- * Greens Bayou Wetlands Mitigation Bank (GBWMB)

1.8 PLANNING PROCESS AND REPORT ORGANIZATION

This GRR was organized to present pertinent information regarding the planning process and potential project impacts. It is intended to meet NEPA requirements for assessing potential adverse impacts on the environment as well as USACE project reevaluation guidelines.

The document is divided into eight primary analytical sections, each dealing with a specific subject area. Sections 1 through 8 and 10 provide information that meets the requirements of NEPA and the GRR planning processes. Section 9 is specific to USACE GRR requirements and supports decisions by the USACE and HCFCF for project approvals.

2.0 PROBLEM IDENTIFICATION

This section presents the results of the first step of the planning process, the specification of water and related land resources problems and opportunities in the Greens Bayou watershed. The section concludes with the establishment of planning objectives and planning constraints, which is the basis for the formulation of alternative plans.

2.1 FLOODING PROBLEMS

Flooding on the flat Texas coastal plain is characterized by slow rise, low velocity, and long duration. Because of the lack of topographic relief and the predominance of thick clay soils in Harris County, floodwaters tend to pool and stand. Some limited topographic relief is created by the development practice of grading streets lower than the surrounding land, thereby allowing roads to function as tertiary drainage conduits from the surrounding urban development. Because of the dual function of roadways for transportation and drainage, vehicles are especially vulnerable to flood damages. The nature of flooding is such that there is no way to escape once the roads are under water other than by wading out on foot or evacuation by boat.

Problems and needs associated with the Greens Bayou watershed were identified and considered during reevaluation of the project. The current major water resource problem in the watershed has been identified as the frequent flooding from lack of adequate stream capacity and development in flood-prone areas. The dynamic growth of residential and commercial development in the watershed has contributed to increased runoff and intensified flood damages. Other current related water resource needs in the watershed identified during reevaluation include recreation, water quality, and natural resources. Water resource needs are discussed in the Buffalo Bayou and Tributaries Feasibility Report as well as in this GRR.

Greens Bayou has experienced flooding problems dating back to the early 1900's. Flooding occurs in the bayou watershed despite several flood control projects constructed by the HCFCF. The watershed contains extensive areas of development, particularly in the middle and upper portion of the watershed between U.S. 59 and Cutten Road. Average annual potential flood damages under existing conditions are estimated at \$19,174,600. The 0.2 percent (500-year) annual exceedance floodplain for the watershed includes an estimated 4,341 structures valued at an estimated \$390 million, which could be inundated to some degree. The potential damages to existing development from inundation during any single 0.2 percent occurrence under 2005 conditions are estimated to exceed \$154 million. The 1 percent (100-year) annual exceedance floodplain includes an estimated 2,869 structures with an estimated value of \$255 million.

The HCFCF has compiled information on 22 flooding events between 1913 and 1984. These events resulted in at least 10 deaths, flooding of hundreds of homes, and damages in excess of \$1 billion.

In a partnering meeting held in April 1995, the HCFCD reported that recent flood damages along Greens Bayou included 157 homes in May 1989, 320 homes in June 1989, 378 homes in 1992, and 22 homes in October 1994.

At the same partnering meeting, neighborhoods that sustained flood damages were identified. Buyouts were considered as a solution for flood damage reduction for the following neighborhoods:

Home Owned Estates	Greens Bayou Estates
Greens Bayou Park	Green River Estates
Hidden Forest	Shady Brook
Forest Acres	

Detention, channelization and buyouts were considered for the following subdivisions:

Oak Knoll Estates	Greenbriar Colony	Northborough
Kenwood Place	Gatewood	Glen Forest Estates
Parkwood Estates	Greenbranch	Woodgate
Sequoia Estates	Greenbriar North	Briar Creek
Castlewood	Southbrook	Greenfield Village
Copper Creek	Cutten Green	Bellmeade
Turtle Lake		

The most severe flooding in the Greens Bayou area occurred in 2001 during Tropical Storm Allison. This storm is considered the flood of record for the study area and the greater Houston area. The storm produced record rainfalls throughout the county, and the lower portion of Greens Bayou was the most severely affected. Up to 28 inches of rain were recorded during a 12-hour period, approaching the physical limits of how much rain could fall during that amount of time in the region. Water actually flowed overland between Greens Bayou and its tributary Halls Bayou, which is a very rare occurrence. Over 15,000 structures were inundated including those structures along the mainstem of Greens Bayou and its tributaries, many of which were outside the one percent annual exceedance floodplain of the mainstem (Off The Charts, Tropical Storm Allison Public Report, Harris County/FEMA, 2002). The photographs displayed on the following pages show the widespread extent of the flooding from stream overflows in flat coastal plains of the study area (as a result of the flood events discussed above).



Provided by HCFCD

Home Owned Estates, June 10, 2001



Provided by HCFCD

Parkwood Subdivision, June 9, 2001



Provided by HCFCF

Woodgate Subdivision, June 9, 2001

2.2 PUBLIC CONCERNS

A number of public concerns have been identified for this study area beginning in the early 1980's. Initial concerns were expressed in the study authorization. Additional input was received through coordination with the Non-Federal Sponsor and coordination with other agencies. A discussion of public involvement is included in Section 8, Public Involvement, Review and Consultation. The public concerns related to the establishment of planning objectives and planning constraints are:

- ♦ Flooding problems are caused primarily by the flat topography in the watershed, the increased rainfall runoff resulting from intense urbanization over the years, and the lack of stream capacity in the bayou and lateral drainage facilities.
- ♦ Runoff to the bayou is further impeded by inadequate storm sewers, lateral drainage ditches, and tributary streams.
- ♦ Future urbanization would increase flooding problems in the future without-project condition despite ongoing activities by local entities to restrict runoff.
- ♦ Environmental impact of authorized project.

2.3 WATER QUALITY NEEDS

Water quality conditions in Greens Bayou are generally poor as a result of nonpoint source and municipal and industrial discharges into the stream. The lower reaches of the bayou are subject to tidal fluctuation. Industrial discharges from various sources also influence the water quality in these reaches. The primary source of the normal flow in the upper reaches of the bayou is effluent from numerous municipal waste treatment plants located throughout the watershed. Improvements of water quality throughout the watershed are needed for habitat and fishery populations and to improve the health and safety of the urban area.

2.4 SOCIAL AND ECONOMIC NEEDS

Flooding in the study area from rainstorms greater than about four inches in several hours adversely affects vehicular movement along transportation corridors. Because of the dual function of roadways for transportation and drainage, vehicles are vulnerable to flood damages. This is generally the level at which nuisance flooding ends and adverse social and economic effects begin.

About 4,341 single and multi-family homes, apartments units, mobile homes and townhouse/condominiums with a total property value of about \$390 million are located within the 0.2 percent annual exceedance floodplain. Over 12,000 residents are at risk in this floodplain. Over 550 commercial, industrial and public structures are in the 0.2 percent annual probability exceedance floodplain. A single occurrence of a flood of this magnitude would result in damages of about \$263 million under current conditions of development.

2.5 NATURAL RESOURCES AND ENVIRONMENTAL NEEDS

Extensive urbanization in the study area and previous channel clearing and enlargement to provide flood relief has resulted in significant alterations to riparian habitat. There has been a substantial decline in population of birds, mammals, reptiles and amphibians with development within the watershed. Much of the wetland and riparian habitat has also been lost or severely damaged, and water quality has declined with increased urbanization. The need exists to improve these conditions.

In recent years considerable public interest has emerged for preserving ecologically and aesthetically sensitive spaces in the Houston area. The environmental setting has been altered from a natural condition by previous locally constructed channel work and by urbanization in the upper reaches. Little natural environmental beauty and riparian habitat remains in the upper reaches. Vegetation in the more sensitive areas, below the confluence with Garner's Bayou, includes stands of mixed pine/hardwood habitat adjacent to the bayou. Bottomland hardwood habitat in the area between U.S. Highway 90 and Normandy Drive are in a nearly mature state. Understory and shrub layers are moderate to dense in this area. Aesthetic improvements, beautification measures, and reestablishment of wildlife habitat are needed along the stream to improve environmental quality, enhance appearance, and improve wildlife resources.

3.0 FORMULATION OBJECTIVES, CONSTRAINTS AND CRITERIA

This section discusses the planning process used to reevaluate the water resources problems and needs of Greens Bayou. As noted in Section 2, the study area was determined to have sufficient flooding problems to warrant Federal participation in the investigation of flood damage reduction solutions. The reevaluation of alternatives is based on the following formulation objectives, constraints and criteria.

3.1 NATIONAL OBJECTIVES

The Federal objective of water and related land resources planning is to contribute to NED consistent with protecting the Nation's environment, in accordance with national environmental statutes, applicable executive orders, and other Federal planning requirements. Water and related land resources project plans shall be formulated to alleviate problems and take advantage of opportunities in ways that contribute to study planning objectives and, consequently, to the Federal objective. Contributions to NED outputs are increases in the net value of the national output of goods and services, expressed in monetary units, and are the direct net benefits that accrue in the planning area and the rest of the Nation. Contributions to NED include increases in the net value of those goods and services that are marketed and also of those that may not be marketed. Protection of the Nation's environment is achieved when damage to the environment is eliminated or avoided and important cultural and natural aspects of our nation's heritage are preserved. Various environmental statutes and executive orders assist in ensuring that water resources' planning is consistent with protection. The objectives and requirements of applicable laws and executive orders were considered throughout the planning process in order to meet the Federal objective.

The USACE has added a second national objective for Ecosystem Restoration in response to legislation and administration policy. This objective is to contribute to the Nation's ecosystems through ecosystem restoration, with contributions measured by changes in the amounts and values of habitat.

3.2 PLANNING OBJECTIVES

Planning objectives are an expression of public and professional concerns about the use of water and related land resources resulting from the analysis of existing and future conditions in the study area. These planning objectives were considered in the development of alternative plans and their evaluation.

One of the primary purposes of these investigations was to formulate a project with less environmental impact for Greens Bayou; focusing on recently damaged areas. Flood damage reduction alternatives as well as the associated environmental and recreational developments of prior studies were investigated. To proceed through the planning process, a viable plan must be formulated which 1) is economically feasible, 2) is in the Federal interest of flood damage reduction and/or environmental restoration, and 3) has non-Federal support.

Based on the problems and needs as discussed in Section 2.1, the following specific planning objectives were considered during the planning process:

- a. Reduce the flood hazard and damage to existing properties within the 0.2 percent annual exceedance probability floodplain of the Greens Bayou study area to a level which would protect against possible loss of life and hazards to health and safety and is publicly accepted, thus, helping to constitute an acceptable plan for the Non-Federal Sponsor;
- b. Contribute to environmental quality by preserving or improving fish and wildlife habitat and open space greenbelt areas;
- c. Preserve, conserve, or improve the environmental and cultural resources of the study area and mitigate for any adverse impacts to the existing natural environment; and
- d. Maintain existing open space areas and recognize the potential for recreation opportunities within the study area.

3.3 PLANNING CONSTRAINTS

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated. The planning constraints identified in this study are as follows:

- a. The project should be limited to the study area within the Greens Bayou watershed.
- b. Alternative plans that solve problems in one area but compound them in other areas should be avoided.
- c. Total benefits must equal or exceed costs for a plan to be considered for Federal participation.
- d. The project must be acceptable to the general public as far as can be established.
- e. Non-Federal Sponsor will not participate in a plan that will worsen conditions downstream.

3.4 FORMULATION AND EVALUATION CRITERIA

Current guidance specifies that the Federal objective of planning is to contribute to the NED consistent with protecting the Nation's environment. Planning rationale used to develop effective long term solutions to the flooding problems of the study area consisted of identifying alternative measures with consideration given to the technical, economic, social, and environmental impacts of each alternative. The following sections discuss the criteria used to develop alternatives to meet the stated objectives of this study.

3.4.1 Technical Criteria

To develop a plan that would satisfy the primary objective of reducing flood damages, the following technical criteria were used in developing, evaluating, and comparing alternative plans:

- ♦ The plan should be economically efficient and effective.
- ♦ The plan must be technically feasible and constructible using engineering methods and equipment available in this region.
- ♦ Plans should provide a project life of at least 50 years.
- ♦ Existing project facilities should be utilized to the maximum extent possible.
- ♦ The plan should be complete within itself and not require additional future improvements other than normal operation and maintenance.
- ♦ The plan should be designed using USACE engineering criteria and regulations related to flood damage reduction alternatives.
- ♦ The plan should conform to the HCFCFCD's design manual criteria.
- ♦ Compute flood frequency along Greens Bayou so that corresponding flood damages can be computed in an economic analysis using a risk-based analysis procedure.

Risk and Uncertainty (R&U) analysis was applied to hydrologic and hydraulics investigations and the economic analysis and are discussed in the respective appendices. R&U identifies and accounts for the uncertainties and reliability of data and forecasting methodology associated with project development.

3.4.2 Economic Criteria

The economic criteria require that tangible benefits attributable to projects exceed project costs. Project benefits and costs are reduced to average annual equivalent values and related in a ratio of BCR. This ratio must exceed unity to meet the NED objective. The following criteria were used to develop plans that achieve the objective of NED and provide a base condition for consideration of other economically unquantifiable factors which may have an impact on project proposals:

- ♦ Selected plans, whether structural, nonstructural, or a combination of both, should maximize excess benefits over costs; however, unquantifiable features must be addressed subjectively.

- ♦ The effectiveness of structural and nonstructural measures should be evaluated on the basis that all future development within the 1.0 percent annual exceedance probability floodplain would be built with first floor elevations at or above the 1.0 percent annual exceedance floodplain level.
- ♦ All measures for flood damage reduction should be evaluated using a 50-year period of analysis and the currently applicable interest rate.
- ♦ Total annual costs should include amounts for operation, maintenance, and relocations, as well as amortization and interest on the investment.

3.4.3 Environmental Criteria

The general environmental criteria include specific measures to maintain or improve environmental quality. The overall environmental considerations are to protect, preserve, and improve existing environmental values and to minimize unavoidable damages to the environment. It is national policy that fish and wildlife resource conservation be given equal consideration with other study purposes in the formulation and evaluation of alternative plans.

This reevaluation will employ the following principles for use in developing, evaluating, and comparing alternative plans:

- ♦ Strive to achieve environmental sustainability. An environment maintained in a healthy, diverse and sustainable condition is necessary to support life.
- ♦ Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of project.
- ♦ Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.
- ♦ Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.
- ♦ Seeks ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycle of our processes and work.
- ♦ Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.
- ♦ Respect the views of individuals and groups interested in USACE activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the Nation's problems that also protect and enhance the environment.

3.4.4 Social and Other Criteria

Plans proposed for implementation should have an overall favorable impact on the social well-being of affected interests, and have an overall public acceptance. Structural and non-structural alternatives must reflect close coordination with interested Federal and State agencies, the HCFCD, the City of Houston, and the affected public. The effects of these measures on the environment must be carefully identified and compared with technical, economic, and social considerations and evaluated in light of public input.

4.0 PLAN FORMULATION

This section describes the development of alternative plans that address the planning objectives, the comparison of those plans and the selection of a plan. It also describes the recommended plan and its implementation requirements.

4.1 PLAN FORMULATION RATIONALE

The planning framework requires a systematic preparation and evaluation of alternative ways of addressing the project problems, needs, concerns, and opportunities while considering environmental factors. The criteria and planning objectives previously identified form the basis for subsequent plan formulation, alternative screening, and ultimately selection of the recommended plan.

The planning process for this general reevaluation study has been driven by the overall objective of developing a comprehensive plan that minimizes the adverse impacts of urban flooding while protecting the Nation's environmental resources. Secondary objectives have been to address other related water resources or environmental problems within the study area.

The first phase of the study process determined the magnitude and extent of the problems along Greens Bayou. Specific locations where recent flood damages occurred were identified. Flood damage reduction alternatives that would meet the existing and long-range future needs of the Non-Federal Sponsor and the public were also identified to be included in reformulation analyses. Since the Non-Federal Sponsor did not support the authorized project, the original formulation was not validated or remodeled for analysis. Therefore the authorized project was not carried throughout plan formulation for comparison since it was not supported. This GRR presents the authorized project and its changes related to the recommended plan. The authorized project will be compared to the recommended plan at the end of plan formulation in order to comply with guidance (ER-1105-2-100).

During the reevaluation phase of the project, lines of communication were opened with Federal, State, and local agencies, private groups, and the affected public. During the course of the study, public notices were sent to inform the Greens Bayou community of the study efforts. These notices solicited public concerns and comments, which would be used during plan formulation.

4.2 INITIAL PLAN FORMULATION

4.2.1 Future Without-Project Condition (No Action)

The expected future without-project condition was first developed for comparison with other alternatives. During initial screening, 21 plans were developed, investigated, and screened to satisfy the objective of minimizing flooding along the stream.

The USACE is required to consider the option of No Action as a viable alternative in any final array of plans to comply with the requirements of the NEPA regulations. The planning process must convincingly establish that Federal involvement is preferred over no action. With the No Action Plan, which is synonymous with the Without-Project Condition, it is assumed that the Federal Government would implement no project. The No Action Plan forms the basis against which all other alternative plans are measured. The existing conditions or the without-project condition is described below.

Economic Condition. Flood damages to existing development were estimated for all property within the most likely future condition (2055) median 0.2 percent annual exceedance probability floodplain of Greens Bayou. Approximately 87 percent of these structures are residential with a cumulative value of approximately \$221 million dollars. An estimated 87 percent of the structures within the existing median 1 percent annual exceedance probability floodplain, with a cumulative value of over \$152 million, are residential. Under existing conditions, the average annual damages are expected to be over \$19 million during the project life. These damage estimates include damages to structures and contents of various types of physical properties classified as residential, commercial, public, or industrial.

Hydraulic Condition. An increase in the volume of runoff associated with watershed urbanization can be attributed to removal of forest and brush cover, grading and draining of shallow ponding areas, and creation of impervious cover. Small development projects and simple land use changes, such as clear cutting timber, are not regulated and will continue to develop in the watershed, thereby impacting runoff. HCFCD manages proposed watershed development projects in an attempt to restrict flow increases, but their authority is limited. It is expected that in the most likely future condition (2055) that an average increase in flow rates will be about 15 percent.

Environment Condition. The Greens Bayou watershed has been impacted by urbanization and development activities. Urban growth and development would be expected to continue in the watershed if no Federal project were constructed. Habitat changes would continue from construction activities. Some upland forest and prairie areas would be converted to urban land types. The removal of wooded and prairie vegetation for development activities would displace wildlife species. For the future without-project, the stream would probably continue to have limited aquatic habitat and fishery populations.

4.2.2 Measures to Address Identified Planning Objectives

A management measure is a feature or activity at a site, which addresses one or more of the planning objectives. A wide variety of measures were considered, some of which were found to be infeasible due to technical, economic, or environmental constraints. Each measure was assessed and a determination made regarding whether it should be retained in the formulation of alternative plans. The descriptions and results of the evaluations of the measures considered are presented below:

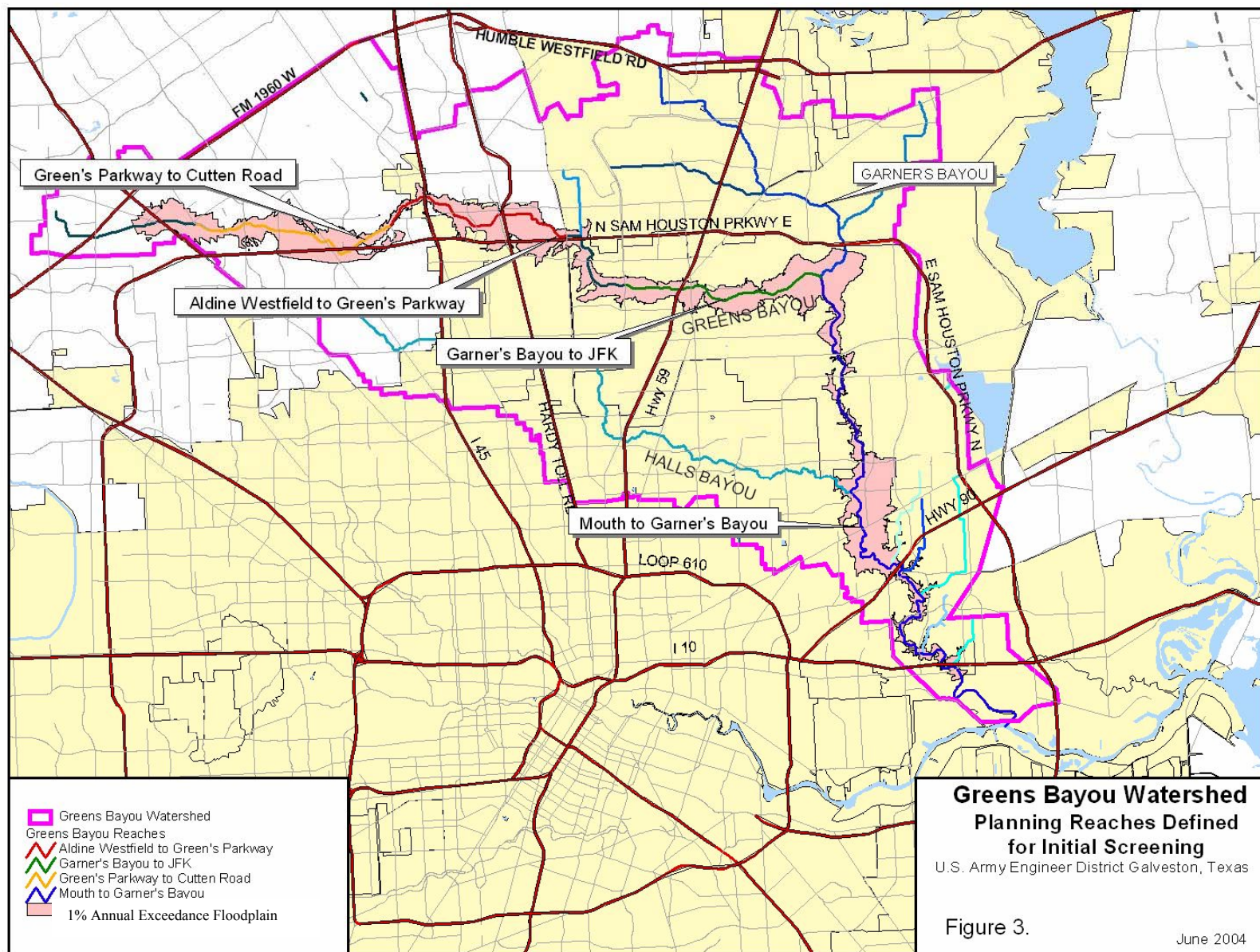
- 1) Non-Structural measures attempt to avoid flood damages by exclusion or removal of damageable properties from flood prone areas. These measures do not affect the frequency of level of flooding within the floodplain; rather they affect floodplain activities. The technique of controlled land use is particularly helpful in planning for future development but is of limited use in highly developed areas. The range of nonstructural measures included the following:
 - ♦ Floodproofing/Raising Structures
 - ♦ Stand-alone Structural Buyout
 - ♦ Residual Structural Buyout
- 2) Structural measures consist of structures designed to control, divert, or exclude the flow of water from flood prone areas to the extent necessary to reduce damages to property, hazard to life or public health, and general economic losses. The structural measures considered were as follows:
 - ♦ Detention
 - ♦ Levees
 - ♦ Channelization

4.2.3 Preliminary Screening of Alternatives

Changing conditions within the watershed and new evaluation criteria required that new information be collected for the reevaluation effort. A new structure inventory, new hydrologic conditions, and new stage-frequency curves were incorporated into the reanalysis as compared to the authorized project. Project benefits were determined in accordance with the most current guidance, ER 1105-2-100 and ER 1105-2-101. In an effort to address the planning constraint set by the Non-Federal Sponsor, the need to mitigate for induced damages downstream was added to all channel plans. Alternative plans were screened based on their damages reduced to structures and content initially.

To facilitate the screening process, initial plan formulation analyses were conducted as follows. With the management measures described above and using engineering judgment, three different channel bottom-widths were assumed for each channel configuration for each planning reach. Hydraulic models were run on the assumed channels, and the results were used to conduct economic analyses. No R&U analyses were conducted for the initial screening.

Equal hydraulic performance was assumed for each configuration, since the volume of the downstream mitigating detention basin was equal to the volume of the linear detention excavation. Therefore both channel configurations were presumed to have equal benefits, but different costs. A tabulation of the average annual benefits and costs for this first iteration of alternatives was computed. Quantity and cost estimates were completed for the channel designs, and net excess benefits were computed. The array of alternatives was analyzed on a screening level basis. Only the major determinate cost items were quantified.



A more detailed analysis would be made on selected feasible alternatives. The stream was broken into four distinctive planning reaches (see Figure 3). The new hydrology produced over 468 stream stations. Economic reaches were derived from these stations.

Planning Reach 1: Mouth to Garners Bayou

This reach was not considered for detention or channelization because of environmental sensitivity and minimal urbanization; buyouts and the raising of structures were considered.

Placement of a ring levee around Forest Acres Subdivision

Alternative plans were developed involving the use of ring levees to provide flood damage protection to the Forest Acres subdivision. Three alternative levee crest elevations were evaluated (Table 5). The plans included consideration of interior drainage facilities.

Table 5					
Levee plans--Planning Reach #1					
Alternative	Cross Section	Crest EL in Ft	Description		
FO-LEV1	97290	56	Ring levee around Forest Acres		
FO-LEV2		58	Subdivision		
FO-LEV3		59			

Planning Reach 2: Garners Bayou to John F. Kennedy (JFK) Boulevard

The second reach was defined from the Garners Bayou confluence to JFK Boulevard. Three structural plans and detention plans were considered for this planning reach to provide flood damage reduction.

The first alternative (Table 6) included an off-line detention basin, with a side overflow weir, at the upstream end of the reach near JFK Boulevard. Three basin sizes were evaluated at 25 percent, 50 percent, and 100 percent of the available depth of the mainstream channel, corresponding to bottom elevations of 57, 53, and 45 feet (all elevations are NVGD 1973 adjusted).

The second alternative involved channel modifications extending from the confluence with Garners Bayou to JFK Boulevard, with a mitigating detention basin at the downstream end. The modified channel would be a trapezoidal grass-lined section with no major realignment of the bayou. Alternative bottom widths of 75-, 105-, and 135-feet for the channel were considered. The detention basins required to mitigate the channel flows would require 960, 1,430, and 1,790 acre-feet of excavated storage capacity, respectively, below elevation 58 feet, plus any overburden.

The third alternative involved channel improvements from JFK Boulevard to the confluence with Garners Bayou, with a linear detention area in the reach. The linear detention area would be a trapezoidal bench cut adjacent to the channel improvement. Three alternative excavations were

considered and would be 110-, 160-, and 200-feet wide with a bottom elevation 8 feet above the existing channel bottom.

Table 6 Screening Plans--Planning Reach # 2				
Detention plans:				
Alternative	Cross Section	Description		
JFK-DET1	130156	Detention basin near JFK Blvd. Assume 30-foot maintenance		
JFK-DET2		fringe berm and 1:3 sideslopes and a 300-ft concrete		
JFK-DET3		capped inlet weir.		
Channel plans with downstream detention:				
Alternative	Cross Sec (D/S)	Bottom Width (Feet)	Mitigating Detention Requirement Feet of Excavation	Description
JFK-CHD1	130156	75	960 below elev +58	
JFK-CHD2		105	1430 below elev +58	Simple trapezoidal, grass lined channel from JFK to Garners Bayou confluence at existing grade and existing alignment.
JFK-CHD3		135	1790 below elev +58	
Channel plans with linear detention:				
Alternative	Channel Description	Bottom Width	Description	
JFK-CHL1	Same as JFK-CHD1'2'&3	110	Linear detention will be a simple trapezoidal bench cut adjacent to the channel improvement.	
JFK-CHL2		160	The detention cut will be densely planted to prevent flow conveyance.	
JFK-CHL3		200		

Planning Reach 3: Aldine Westfield to Greens Parkway

The third reach extended from Aldine-Westfield Road upstream to Greens Parkway. Two structural alternative plans and detention plans were considered for this planning reach to provide flood damage reduction (Table 6).

The first plan included an off-line detention basin, with a side overflow weir, at the upstream end of the reach near Greens Parkway. Three basin designs were analyzed at 25 percent, 50 percent, and 100 percent of the available depth of the mainstream channel to determine their feasibility. The proposed basins were assumed to have a maintenance fringe berm around the excavation.

The second plan included channel modifications from Greens Parkway to Aldine-Westfield Road. The improved channel would be a trapezoidal, grass-lined section with no major realignment and at existing grade. Channel bottom widths of 75-, 90-, and 105-foot were evaluated. The plan would also include a mitigating detention basin at the downstream end of the reach.

Table 7 Screening Plans--Planning Reach #3						
Detention plans:						
Alternative	Cross Section	Description				
GP-DET1	178743	Detention near Greens Parkway or Spears Gears Rd.				
GP-DET2		Assume 30-foot maintenance fringe berm and 1:3				
GP-DET3		sideslopes and a 300ft concrete capped inlet weir.				
Channel plans with downstream detention:						
Alternative	Cross Sec (D/S)	Bottom Width (Feet)	Mitigating Detention Requirement Feet of Excavation	Description		
GP-CHD1	178743	75	790 below elev +73	Simple trapezoidal, grass lined channel from Greens Parkway to Aldine Westfield Road at existing grade and existing alignment.		
GP-CHD2		90	1180 below elev +73			
GP-CHD3		105	1480 below elev +73			

Planning Reach 4: Greens Parkway to Cutten Road

The fourth reach was defined from the Greens Parkway to Cutten Road. Two alternative structural plans involving channelization and detention were considered for this planning reach to reduce flood damages (Table 8).

Table 8 Screening Plans--Planning Reach # 4						
Channel plans with downstream detention:						
Alternative	Cross Sec	Bottom Width (Feet)	Mitigating DetentionRequirement Feet of Excavation	Description		
CUT-CHD2	206328	40	760 below elev +92	Simple trapezoidal, grass lined channel from Cutten Road to Greens Parkway at existing grade and existing alignment.		
CUT-CHD3		55	950 below elev +92			
Channel plans with linear detention:						
Alternative	Channel Description	Bottom Width	Description			
CUT-CHL1	Same as CUT-	100	Linear detention will be a simple trapezoidal bench cut			
CUT-CHL2	CHD1,2"0	150	adjacent to the channel improvement. The detention cut will be			
CUT-CHL3		188	densely to planted prevent flow conveyance.			

The first alternative involved channel improvements from Cutten Road downstream to Greens Parkway, with a mitigating detention site at the downstream end of the reach. The improved

channel would be a trapezoidal, grass-lined section constructed at existing grade and alignment. Several channel sizes were considered.

The second alternative involved channel modifications from Greens Parkway to Cutten Road with linear detention. The improved channel would be a trapezoidal, grass-lined section constructed at existing grade, with no major realignment of the bayou. The linear detention would be a simple trapezoidal bench cut adjacent to the channel modifications. Several bottom widths for the detention basins were considered.

4.2.4 Preliminary Plans Eliminated from Further Consideration

There was no channel modification solutions considered for Planning Reach 1 of the bayou extending from the “Mouth to the Garner’s Bayou” confluence because of its environmental sensitivity. This reach of the stream had not been channelized to any great extent, since it contains wetlands and riparian areas that are extremely environmentally sensitive. The most sensitive area is bound by Normandy Drive to the south and Highway 90 to the north. A segment of lower Greens Bayou is adjoined by bottomland forest and urbanized woodlands and has not been channelized. Early discussions regarding mitigation efforts for this planning reach indicated that the cost of mitigation would be excessive and the adverse environmental impacts of a plan could be the loss of riparian and wooded upland vegetation. Therefore, this reach was considered for nonstructural measures only.

A ring levee around the Forest Acres Subdivision and a buyout of floodplains were considered for this area. An initial economic analysis was performed on ring levee alternatives. The levee crests were evaluated for levels of protection at the 4 percent, 2 percent and 1 percent annual exceedance probability floodplains. The average annual construction cost was significantly higher than the average annual damages reduced producing a less than unity BCR (Table 9). Therefore, the ring levee was not economically justified. The buyout alternative will be discussed in Section 4.4.5.

Table 9			
Benefit-to-Cost Ratio			
Alternative Name	Damages Reduced*	AAE Cost*	Benefit-to-Cost Ratio
FO-LEV1	\$27,360	\$573,417	0.047
FO-LEV2	\$27,360	\$606,869	0.045
FO-LEV3	\$27,360	\$628,807	0.043

FY 97 and 8.625% interest rate

In addition, the measure of raising structures was considered for Planning Reach 1 of the stream. An effective way to protect a house from surface flooding is to raise it above the design flood level. This measure was not pursued as the HCFCD is not able to construct improvements that benefit only individual properties and the raising of structures would constitute such an

improvement. There would be no clear public benefit, which would make it an unconstitutional gift of public funds under Texas law. Secondly, since the raising of structures would be on a voluntary basis, there is no means to guarantee the level of benefit determined in plan formulation. Finally, a County ordinance requires that structures (new development) to be built or substantially improved (which would include elevating) within the 1 percent annual exceedance floodplain must have their first floor at an elevation of 1.5 feet above the base flood elevation.

Structural alternatives were considered for the stream extending from the Garner's Bayou confluence to the Cutten Road Bridge. Planning Reaches 2, 3, and 4 addressed high damage areas identified by the Non-Federal Sponsor and verified by existing condition hydraulics and economics. Structural measures involving channelization automatically included mitigating detention to comply with the Non-Federal Sponsor's goal not to induce damages downstream from the channel reach. Planning reaches 2 and 3 did not produce any plans with greater than unity BCR (Table 10).

Table 10						
Intital Screening Alternatives						
FIRST SCREENING - FY97 (Cost in 2001)						
SEGMENT	PLAN NAME*	AVERAGE ANNUAL BENEFITS**	FIRST COSTS	AVERAGE ANNUAL COSTS	NET EXCESS BENEFITS**	Benefit to Cost Ratio
Garner's Bayou to JFK Station 100307 - 130061	JFK-DET1	\$991.44	\$62,028.5	\$3,866.86	(\$2,875.41)	0.26
	JFK-DET2	\$1,321.34	\$69,270.5	\$4,318.33	(\$2,996.98)	0.31
	JFK-DET3	\$1,679.34	\$99,552.4	\$6,206.09	(\$4,526.75)	0.27
	JFK-CHD1	\$1,078.03	\$22,193.2	\$1,383.52	(\$305.50)	0.78
	JFK-CHD2	\$1,202.41	\$30,075.5	\$1,874.91	(\$672.50)	0.84
	JFK-CHD3	\$1,274.40	\$37,994.6	\$2,368.58	(\$1,094.18)	0.54
	JFK-CHL1	\$1,078.03	\$27,404.9	\$1,708.42	(\$630.39)	0.63
	JFK-CHL2	\$1,202.41	\$37,782.2	\$2,355.34	(\$1,152.94)	0.51
	JFK-CHL3	\$1,274.40	\$46,734.3	\$2,913.42	(\$1,639.02)	0.44
Aldine-Westfield to Greens Parkway Station 144415 - 169973	GP-DET1	\$1,184.76	\$35,304.5	\$2,200.88	(\$1,016.12)	0.54
	GP-DET2	\$1,176.81	\$42,841.5	\$2,670.74	(\$1,493.93)	0.44
	GP-DET3	\$1,386.80	\$59,567.2	\$3,713.42	(\$2,326.62)	0.37
	GP-CHD1	\$1,090.77	\$28,381.8	\$1,769.32	(\$678.55)	0.62
	GP-CHD2	\$1,290.85	\$39,922.7	\$2,488.78	(\$1,197.94)	0.52
	GP-CHD3	\$1,452.47	\$51,425.9	\$3,205.89	(\$1,753.42)	0.45
Green's Parkway to Cutten Road Station 169973 - 206328	CUT-CHD1	\$1,061.69	\$19,296.0	\$1,202.91	(\$141.22)	0.88
	CUT-CHD2	\$1,510.53	\$23,855.0	\$1,487.12	\$23.40	1.02
	CUT-CHD3	\$2,009.02	\$27,236.7	\$1,697.93	\$311.09	1.18
	CUT-CHL1	\$1,061.69	\$20,520.8	\$1,279.27	(\$217.58)	0.83
	CUT-CHL2	\$1,510.53	\$27,169.1	\$1,693.72	(\$183.20)	0.89
	CUT-CHL3	\$2,009.02	\$32,136.8	\$2,003.4	\$5.6	1.00
*JFK-DET1-3 = Upstream detention only - 25% depth, 50% depth, and 100% depth						
JFK-CHD1-3 = Channel with downstream mitigating detention - 75-ft bottom width, 105-ft bottom width, and 135-ft bottom width						
JFK-CHL1-3 = Channel with adjacent linear detention - 110-ft bottom width, 160-ft bottom width, and 200-ft bottom width						
GP-DET1-3 = Upstream detention only - 25% depth, 50% depth, and 100% depth						
GPCHD1-3 = Channel with downstream mitigating detention - 75-ft bottom width, 90-ft bottom width, and 105-ft bottom width						
CUT-CHD1-3 = Channel with downstream mitigating detention - 25-ft bottom width, 40-ft bottom width, and 55-ft bottom width						
CUT-CHL1-3 = Channel with adjacent linear detention - 100-ft bottom width, 150-ft bottom width, and 188-ft bottom width						
** Average annual benefits based on 0-ft floor correction						
***Figures in bold reflect net excess benefits of anchor component						

October 2001 price level and 5.625% interest rate

4.2.5 Conclusions from the Preliminary Screening

Quantity and cost estimates were completed for the channel designs, and BCRs computed. The major cost items were quantified. Only planning reach 4 provided viable opportunities. The plan named CUT-CHD3 resulted with the greatest net excess benefits and produced a greater than unity BCR as shown in Table 9. This plan consisted of an earthen channel, 55 feet wide, extending from the bridge at Greens Parkway to the bridge at Cutten Road, with a downstream mitigating detention basin. This plan was optimized in the second screening iteration and is further explained in Section 4.4.3.

As part of the screening level analysis of components, stand-alone nonstructural buyout plans were developed for the 50-, 20-, and 10-percent annual exceedance probability floodplains along the entire main stem of Greens Bayou. These plans consisted of floodplain evacuation and removal of residential and nonresidential structures in various floodplains. These plans were revised during the second screening to comply with guidance in Section 219 of the WRDA 1999, Nonstructural Flood Control Projects published in January 22, 2001. The results of this analysis are discussed in Section 4.4.6.

4.3 Refinement of the Hydrology Before the optimization of the CUT-CHD3 plan components was conducted, a review of the hydrology used in the initial screening exercise revealed a rainfall error that was corrected with a revision of the without-project condition water surface profiles. These revisions produced slightly lower flood stages in the channel reach but a more pronounced lowering of profiles in the downstream reaches of the Bayou. Overall, the without-project average annual equivalent damages to structures and contents declined about 12.5 percent with the adoption of the revised hydrology holding the October 2001 price level and 5.625 percent discount rate constant. Table 11 provides a comparison in average annual equivalent damages expected to occur to structures and their contents during the project life in the without-project condition.

The greatest differences between the original without-project condition and the revised without-project condition are the average annual damages in the lower segment of the stream upstream of Imperial Valley. The flood damage reduction features within this portion of the stream impacted by the rainfall correction did not produce sufficient net excess benefits to be carried forward. Lowering the without-project condition damages to the revised without-project condition did not improve their economic efficiency or their competitive potential. Therefore, the results of the initial screening did not change.

Table 11				
Average Annual Equivalent Damages, 5.625%				
to Structures and their Contents				
Revised Without-project Condition				
Greens Bayou				
REACH	REACH LIMITS		Without	
NAME	LOWER	UPPER	Project	percent
	CROSS-SECTION		Revised	distribution
BLO-I10	16083	17638	\$4,172,000	21.8%
BLO-HALLS	20610	63860	\$2,289,000	11.9%
ABUVHALL	64366	86100	\$184,000	1.0%
GARNERSCUT	91824	100307	\$71,000	0.4%
BLOHWY59	104390	121990	\$343,000	1.8%
HWY59-IMPVALLEY	122432	161049	\$4,333,000	22.6%
		Subtotal	\$11,392,000	59.4%
163269	REACH	163269	\$327,000	1.7%
165169		165169	\$360,000	1.9%
167017		167017	\$483,000	2.5%
168600		168600	\$14,000	0.1%
168996		168996	\$73,000	0.4%
169973		169973	\$10,000	0.1%
170999		170999	\$75,000	0.4%
173701		173701	\$34,000	0.2%
174793		174793	\$0	0.0%
175597		175597	\$1,000	0.0%
176483		176483	\$120,000	0.6%
178067		178067	\$172,000	0.9%
179017		179017	\$145,000	0.8%
180654		180654	\$63,000	0.3%
181816		181816	\$0	0.0%
183453		183453	\$125,000	0.7%
186594		186594	\$540,000	2.8%
187199		187199	\$1,191,000	6.2%
187892		187892	\$744,000	3.9%
189892		189892	\$3,000	0.0%
192611		192611	\$584,000	3.0%
195119		195119	\$1,219,000	6.4%
198393		198393	\$330,000	1.7%
198689		198689	\$44,000	0.2%
200453		200453	\$311,000	1.6%
202037		202037	\$0	0.0%
203779		203779	\$115,000	0.6%
204782		204782	\$493,000	2.6%
206328		206328	\$208,000	1.1%
		subtotal	\$7,783,000	40.6%
		average annual equiv total	\$19,175,000	
		Present worth equivalents	\$318,790,000	

October 2001 price levels and 5.625% interest rate

4.4 PLAN FORMULATION (SECOND SCREENING)

4.4.1 Introduction of Section 575 Guidance

Section 575 of the Water Resources Development Act of 1996 provided further guidance on evaluating the Greens Bayou project. The Section reads:

“(a) IN GENERAL – During any evaluation of economic benefits and costs for projects set forth in subsection (b) that occurs after the date of the enactment of this Act, the Secretary shall not consider flood control works constructed by non-Federal interests within the conditions existing prior to construction of the project.

(b) SPECIFIC PROJECTS. – The projects to which subsection (a) apply are-

- (1) the project for flood control, Buffalo Bayou Basin, Texas, authorized by section 203 of the Flood Control Act of 1954 (68 Stat. 1258);
- (2) the project for flood control, Buffalo Bayou and tributaries, Texas, authorized by section 101(a) of the Water Resources Development Act of 1990 (104 Stat. 4610); and
- (3) the project for flood control, Cypress Creek, Texas, authorized by section 3(a)(13) of the Water Resources Development Act of 1988 (102 Stat. 4014).

The apparent intent of this legislation is to ensure that reevaluations of the authorized, but uncompleted, Federal flood control projects reflect conditions that existed when the Federal projects were originally authorized. The sponsor has developed some features of the authorized projects along with additional features intended to further increase the level of protection. The sponsor does not want its work to jeopardize the economic justification of the authorized Federal projects.

To comply with this legislation, specific procedures were developed. These included:

1. Exclude non-Federal flood control works completed prior to the evaluation of benefits and costs from the existing and future “without-project” condition descriptions. These “without-project” conditions will provide the baseline for the next step, which includes the proposed Federal project alternatives.
2. Exclude the same completed non-Federal flood control works from the “with-project” conditions for each alternative considered. Compare these “with-project” conditions to the step 1 “without-project” conditions to determine the incremental benefits, costs, and other impacts for each alternative. Recommend a plan, possibly the No Action Plan, for implementation based on these analyses.
3. Combine the completed non-Federal flood control works with the recommended Federal project to form a total project. Identify the total project output.
4. Reexamine and possibly modify the design and operation of the recommended Federal project to more efficiently achieve the total project output. The total project output should not be compromised without the sponsor’s concurrence.

The non-Federal flood control works that have been developed within the watershed include the following:

1. Basin P500-01 downstream of North Lake Houston Parkway.
2. Channelization constructed by the HCFCD between basin P500-01 and Garners Bayou.
3. Floodplain storage reclamation structure at station 973+00.
4. Basin P500-02 just downstream of Cutten Road
5. Structural buyout by the Federal Emergency Management Agency post Tropical Storm Allison

The Section 575 analyses were applicable only to the basin (P500-02, within the project area) just downstream of Cutten Road. In 2001 after Tropical Storm Allison, FEMA's Hazard Mitigation Grant Program and HCFCD funded the purchase of 119 structures within the 0.2 percent annual exceedance floodplain of the main stem of Greens Bayou. The evaluation of the effects of the basin at Cutten Road and the FEMA buyouts was applied to the recommended plan in Section 4.5.2.

4.4.2 Basis for Second Screening Iteration

A review of the alternatives was performed and detailed cost estimates were developed. Project and economic costs use standard USACE practices in Microcomputer Aided Cost Engineering System (MCACES) format. The cost included estimates for lands and damages, relocations, channel construction, engineering and design, supervision and administration, and allowance for contingencies. Hydraulic analysis determinations were made for two different watershed development conditions: 1) Near Term Condition, which represents watershed condition at the beginning of the project life (2005) and the 2) Most Likely Future Condition, which represents the watershed conditions estimated to exist near the end of the project life (2055). Hydrologic input was economically evaluated for the following measures.

4.4.3 Channel Optimization

Prior to the start of this iteration, the non-Federal flood control work, Cutten Road basin, was removed from the hydrologic models per Section 575 guidance. The screening level alternatives analysis (CUT-CHD 3) produced a channel improvement in the upstream reaches of Greens Bayou as the component with the greatest net excess benefits. This channel improvement was optimized to refine its economic efficiency. The length of the channel was adjusted to concentrate on the reaches with the highest damages. Cutten Road was then determined to be the most reasonable upstream limit for the study reach. The cross-sections extending from Greens Parkway to Veterans Memorial Drive displayed minimal damages. A field check verified a lack of structures between Greens Parkway and Veterans Memorial Drive.

As a result, channel widths were varied in 30-foot increments for a channel segment that ran from Veterans Memorial Drive, cross-section 187199, to Cutten Road at cross-section 206328. Veterans Memorial Drive is also named Stuebner-Airline Road. A fundamental assumption made with the optimization process was that all downstream rises in water surface profiles induced by the channel modification would be mitigated up to the 1 percent annual exceedance

probability event with a detention basin located within the downstream portion of the channel reach. This operational assumption was consistent with the Non-Federal Sponsor's requirement to prevent any increase in the downstream water surface profile above that which would be expected in the "most likely future" without-project condition. The Non-Federal Sponsor, as a standard business practice and to comply with local regulations in response to FEMA requirements for stormwater management, mitigates induced flows to bring the 1 percent chance event within the stage of the without-project condition. As stated in Section 3, the USACE adopted this planning constraint early on in the planning process to conform to the Non-Federal Sponsor's criterion for public acceptability and implementability. Downstream detention was a publicly acceptable and implementable measure to ensure that downstream impacts would be returned to the future without-project condition. This methodology has been used during analysis in the Greens Bayou Limited Reevaluation Report, which had been approved by HQUSACE. For that reason, this methodology was brought forward. While this method does not expressly identify induced damages, the cost of the fully mitigating basin represents the cost of those induced damages. The costs of the basin along with the cost of the channel is compared against benefits produced solely within the channel reach. However, when it was realized that USACE guidance required that mitigation for downstream impacts be economically justified within the impact reach, re: ER 1105-2-100, E-18, (f), hydrologic and economic analyses were undertaken to discover the full effect of induced flows.

These plans would reflect a trapezoidal earthen channel that would be cut on one side of the bayou only (south side only with the exception of Cutten Road to just beyond Cutten Road basin and West Greens Road to Veterans Memorial). Three variations of an earthen, trapezoidal channel were analyzed; 30-foot, 60-foot, 90-foot bottom widths. Side slopes for the different channel sizes are 1v on 3h except for a 3000-foot segment just downstream of Bammel N. Houston Road, which may require 1v on 4h based on slope stability. A description of each of these structural plans follows.

- ♦ The 30-foot Channel Plan. This plan consists of an earthen, trapezoidal channel with 30-foot bottom width; 1v on 3h side slopes, extending from Veteran's Memorial Drive to Cutten Road. A downstream mitigating detention basin designed to return the water surface elevations downstream from the channel modification to the without-project condition accompanies this plan. The detention basin is an off-channel storage area, requiring 120 acres of land, with a lateral spillway (overflow side weir) located on the south side of the bayou. It is generally situated within an area that is bounded on the west by Antoine Road, on the south by the Sam Houston Tollway, on the east by Briarcreek Subdivision and on the north by W. Greens Road. The overflow side weir is located downstream of Antoine along the south bank of the bayou.
- ♦ The 60-foot Channel Plan. This plan is exactly like the 30-foot Channel plan, with the following exceptions: it has a 60-foot bottom width, and the detention basin requires 125 acres of land.
- ♦ The 90-foot Channel Plan. This plan is the same as the 30-foot Channel plan as well, with the following exceptions: it has a 90-foot bottom width channel and a detention basin with 130 acres of land.

This optimization process demonstrated that the 60-foot wide channel segment maximized net excess benefits and, so, was identified as the structural anchor component for further damage reduction opportunities. The 60-foot channel and mitigating basin produced net excess benefits of \$19.5 million in present worth equivalents or \$1.175 million in average annual equivalents, discounted at 5.625 percent. The BCR was 2.0 and is shown in Table 12.

***Channel Optimization with Mitigating Detention
Between Veteran’s Memorial and Cutten Road
(In thousands of dollars)***

Table 12					
Channel Size	Residual AAE Damages	Damages Reduced**	AAE Cost	Net Excess Benefits**	BCR
30-Foot	\$17,516	\$1,659	\$1,129	\$530	1.5
<i>60-Foot</i>	<i>\$16,772</i>	<i>\$2,403</i>	<i>\$1,228</i>	<i>\$1,175</i>	<i>2.0</i>
90-Foot	\$16,429	\$2,746	\$1,663	\$1,083	1.7

♦ Dollars reflect October 2001 price levels & 5.625% interest rates

**Average Annual Equivalents (AAE)

In effect, the economic damages prevented within the channel segment reach justified not only the channel but also a mitigating detention basin, the cost of which functioned as a proxy value for induced damages. The channel segment was optimized incorporating the cost of the mitigating basin as well as the channel. However, the assumption made with regard to mitigating downstream runoff from the structural plan deviated from published USACE guidance. ER 1105-2-100, E-18, (f) states that “mitigation of induced damages is appropriate when economically justified or there are other reasons of safety, economic or social concerns, or a determination of a real estate taking... has been made.” Therefore, the economic justification for mitigation must be derived from the damages prevented in the downstream impact area rather than within the project reach.

4.4.4 Basin Optimization

Mitigation had been prematurely applied to the structural channel segment optimization since opportunities for further flood damage reduction had not yet been exhausted. This realization spurred optimization of what had once functioned as the mitigating detention basin. Therefore, the detention basin was optimized as a flood damage reduction feature. The basin not only mitigates for induced increased flows downstream of the channelized reach but it creates synergism with the channel to reduce flood damages within the channelization reach and further downstream.

Hydraulically, a baseline channel was developed for comparison purposes so that a basin could be optimized. This channel would not have any included attenuating features (unlike the optimized channel). The detention basin was varied in size and reevaluated with the 60-foot channel using the unsteady flow model, UNET (USACE, 1997). Trial sizes used for this detention basin were 50-, 65-, 80-, 93-, and 108-acres. A detention basin, near West Greens Road, was modeled as an off-channel storage area with an overflow side-channel weir. The basin site was evaluated as two storage compartments connected by four 10X10-foot concrete box culverts through West Greens Road. Thirty acres were assessed north of West Greens Road and the remaining area was assessed south of West Greens Road. Two weir sizes were optimized along with each basin size. This process began with the development of five differing basin sizes and two weir structures for evaluation. After the first four basin sizes were evaluated, it was determined that “weir 2” performed more efficiently than “weir 1.” Table 13 displays the outcome of the optimization process and shows that the 60-foot channel in place with the 108-acre basin with weir 2 produces the greatest net excess benefits.

***Optimization of Detention Basin w/60-foot Channel
(In thousands of dollars)***

Table 13					
Channel Size	Residual AAE** Damages	Damages Reduced**	AAE Cost	Net Excess Benefits**	Benefit-to- Cost Ratio
50-Acre Basin/Weir 2	\$16,363	\$2,811	\$708	\$2,029	3.6
65-Acre Basin/Weir 2	\$15,847	\$3,328	\$918	\$2,409	3.6
80-Acre Basin/Weir 2	\$14,568	\$4,606	\$1,085	\$3,521	4.2
93-Acre Basin/Weir 2	\$14,164	\$5,011	\$1,211	\$3,800	4.1
<i>108-Acre Basin/Weir 2</i>	<i>\$13,972</i>	<i>\$5,203</i>	<i>\$1,391</i>	<i>\$3,812</i>	<i>3.7</i>

♦ Dollars reflect October 2001 price levels & 5.625% interest rates

**Average Annual Equivalents (AAE)

All induced economic damages from the 60-foot channel segment are mitigated with a 65-acre detention basin, weir 2 configuration. At that basin size, induced damages reach zero dollars. The 65-acre, weir 2 basin adds an incremental benefit over the 60-foot channel without basin of \$3,974,000 average annual equivalent dollars at an incremental cost of \$727,000 average annual equivalent dollars. The net excess benefits for the 65-acre basin mitigating to the 0.2 percent chance event is \$3,248,000 and produces a BCR of 4.6.

The plan maximizing net economic benefits has been identified in the reformulation phase as the 60-foot channel with the 108-acre detention basin with a weir 2 configuration. The 108-acre, weir 2 basin adds an additional \$1,875,000 benefits over and above the 65-acre, weir 2 basin for an incremental cost difference of \$471,000, on an average annual equivalent basis. The net excess benefits from the incremental difference are \$1,404,000 with a BCR of 4.0. Nevertheless, the 108-acre basin did not break the optimization curve in net excess benefits. The paucity of additional land required for continued basin enlargement suggested a highly probable negative outcome from additional analyses. The HCFCD was asked if it sought to consider a larger basin. The Non-Federal Sponsor decided against evaluating a larger basin, as it would increase the cost of the project. At that time, the Non-Federal Sponsor invoked its prerogative under the conditions of ER-1105-2-100, paragraph 2-3f(4) and asked that the optimization process cease with the 108-acre basin. This analysis indicated that the basin, modeled with a surface area of 108 acres could provide further flood damage reduction benefits in combination with the 60-foot bottom width channel than as merely functioning as a channel mitigation measure. In combination these features function as a system contributing greater benefit, better performance and have less adverse impact through synergism following guidance in EM 1110-2-1419 Section 10, 10-1.

The 108-acre basin was determined to be the optimal basin with the greatest net excess benefits. The 108-acre detention basin would be located immediately downstream of the channel and situated within an area that is bounded on the west by Antoine Road; on the south by the Sam Houston Tollway and a U-Haul facility; on the east by Briarcreek Subdivision; and, on the north by Greens Bayou. West Greens Road separates the basin into two parts as shown in Figure 4.

4.4.5 Evacuation/Buyout of Residual Floodplain

The optimized channel enlargement consists of an earthen trapezoidal channel with a 60-foot bottom width and 1v on 3h side slopes extending from Veterans Memorial Drive to Cutten Road accompanied by a 108-acre detention basin. These features result in nearly a 24 percent reduction in average annual equivalent damages within the 0.2 percent annual exceedance probability floodplain. There remain residual damages with which to formulate additional components. However, environmental constraints in the downstream reaches of Greens Bayou dictated a nonstructural approach to subsequent damage reduction. With identification of these optimized features, a residual floodplain remains that contains 20 structures within the 50 percent annual exceedance probability floodplain; 164 within the 20 percent annual exceedance probability floodplain; and 388 structures within the 10 percent annual exceedance probability floodplain based on first-floor elevations. An evacuation/buyout analysis was performed within the residual floodplains of these probability events.



Figure 4 – Detention Basin

Structures that were purchased by FEMA under the Hazard Mitigation Grant Program (HMGP) following Tropical Storm Allison in June 2001 were removed from the structure inventory prior to the evacuation/buyout evaluation. The evacuation/buyout analysis follows USACE guidance for Section 219 WRDA 99. The Galveston District provided both project and economic costs for the evacuation of properties in compliance with Section 219. The economic costs and benefits of each buyout alternative are displayed in Table 14. This analysis indicated the nonstructural plans in the residual floodplains were not economically justified. Benefits from buyouts were not augmented with economic benefits that might be derived from new uses of the evacuated floodplain, i.e., recreation, because of the patchwork effect that the target properties would produce if vacated. None of the buyout plans for the residual floodplains produced parity of benefits to costs.

***Nonstructural Buyout of Floodplains
Residual to the 60-Foot Channel and 108-AC Basin
Section 219 Compliant***

Table 14					
Annual Exceedance Floodplain	Number of Structures	Damages Reduced**	AAE Cost	Net Excess Benefits**	BCR
50% Res	15	\$125,002	\$136,735	(\$11,733)	0.91
50% Res & Non-Res	20	\$329,948	\$670,089	(\$340,141)	0.49
20% Res	148	\$897,955	\$996,431	(\$98,476)	0.90
20% Res & Non-Res	164	\$2,217,112	\$2,287,901	(\$70,789)	0.97
10% Res	338	\$1,813,285	\$2,117,790	(\$304,505)	0.86
10% Res & Non-Res	388	\$3,404,132	\$7,486,174	(\$4,082,042)	0.45

Dollars reflect October 2001 price levels & 5.625% interest rate

4.4.6 Evacuation/Buyout Alternative

As referenced in the “Initial Screening of Alternatives” section, consideration of nonstructural alternatives in flood damage reduction studies was investigated as required by Section 73 of WRDA 74. This alternative is single purpose and independent of structural measures. During the initial screening-level plan formulation for solutions to flooding on Greens Bayou, plans were developed to evacuate the floodplains of 50-, 20-, and 10-percent annual exceedance probability events. These plans extended the full length of the bayou and were distinguished by buyout of residential only or both residential and nonresidential properties within each respective floodplain considered.

In January 2001, Section 219 of WRDA 99, Nonstructural Flood Control Projects was enacted. This directed the USACE to base the economic analysis of real estate on the economic cost to avoid double counting benefits (rather than the financial cost as defined in existing real estate guidance). In implementing this requirement, the calculation of benefits for nonstructural and structural measures would be similar. A reanalysis of stand-alone nonstructural buyout was

initiated in order to comply. In doing so, the total present worth equivalent damages expected to accrue to structures and contents over the period of analysis were compared with the first cost of purchasing those properties as though they were located outside the 1-percent annual exceedance probability floodplain. As shown in Table 15, the buyout of the residential structures lying within the 20-percent annual exceedance probability floodplain produced the greatest net excess benefits amounting to \$1.3 million in average annual equivalents.

***Nonstructural Bayou Section 219 Compliant
Screening Level Component (entire stream)
(In thousands of dollars)***

Table 15					
Annual Exceedance Floodplain	Number of Structures	Damages Reduced**	AAE Cost	Net Excess Benefits**	Benefit-to-Cost Ratio
50% Res	14	\$323	\$99	\$224	3.3
50% Res & Non-Res	20	\$680	\$449	\$231	1.5
20% Res	249	\$2,516	\$1,912	\$604	1.3
20% Res & Non-Res	270	\$5,593	\$4,257	\$1,336	1.3
10% Res	405	\$4,726	\$6,490	(\$1,764)	0.7
10% Res & Non-Res	444	\$8,716	\$13,213	(\$4,497)	0.7

**Dollars reflect October 2001 levels & 5.625%*

***Average Annual Equivalent (AAE)*

These nonstructural plans were compared with the structural plans to identify the most economically efficient component.

4.5 COMPARISON OF ALTERNATIVES

Comparison is the fifth step in the planning process, which is based on the evaluation of the impacts of the alternatives. The more detailed evaluations of the impacts of the alternatives are presented in Section 5, Environmental Consequences.

4.5.1 Maximization of Net Excess Benefits

As a result of plan formulation during the reevaluation phase, four vital plans were developed as flood damage reduction solutions. These plans include: 1) a 60-foot bottom width trapezoidal channel with mitigating basin; 2) a 60-foot bottom width channel with 108-acre detention basin plan; 3) stand-alone nonstructural evacuation/buyout plan; and combination plan 4) 60-foot bottom width channel/108-acre detention basin with residual evacuation/buyout plan. Of these plans evaluated for Greens Bayou, Plan 2 is considered to be the most cost effective and maximizes net excess benefits over costs and is the Recommended Plan. This plan identified as the plan maximizing net economic benefits is recommended by the USACE and the Non-Federal Sponsor as the Recommended Plan. The alternative plans are displayed in a comparative format in Table 16.

Table 16***				
Alternative Plans				
Alternative Plan	Damages Reduced AAE**	AAE Cost**	Net Excess Benefits (AAE**)	BCR
Structural				
<i>60-Foot Channel w/mitigating basin</i>	\$2,403	\$1,228	\$1,175	2.0
<i>60-Foot Channel w/108-Acre Basin/Weir 2</i>	<i>\$5,203</i>	<i>\$1,391</i>	<i>\$3,812</i>	<i>3.7</i>
Non-Structural				
<i>20% AEF* Residential & Non- Residential</i>	\$5,593	\$4,257	\$1,336	1.3
Structural/Non-Structural				
<i>60-Foot Channel w/ 108-Acre Basin/Weir2 w/Residual Buyout of 50% AEF*</i>	\$5,328	\$1,528	\$3,800	3.5

Dollars reflect October 2001 levels & 5.625% interest rate, thousands of dollars

*Annual Exceedance Floodplain

**Average Annual Equivalent (AAE)

***Damages to Structures and contents only

Note: The average annual damages in the without-project condition equal \$19,175,000

4.5.2. Section 575 Analysis of the NED Plan

To meet the intent of the legislation, the without-project condition for Greens Bayou was formulated without consideration of ongoing construction and property relocations within the study area. Only after the plan maximizing net economic benefits was developed and fully evaluated was additional analysis performed, testing the effect of activities by non-Federal interests. Two activities had the potential for altering either the hydrologic or economic profile of the study area—the construction of the Cutten Road Basin and the purchase and demolition of 119 properties along the main stem of Greens Bayou following Tropical Storm Allison, which occurred June 2001. FEMA’s HMGP and the HCFCD funded the buyouts. Table 16 displays the distribution of the properties purchased under the HMGP within the floodplains of Greens Bayou. The Cutten Road Basin with Weir Configuration 2 further reduces flood damage along the main stem on an average annual basis of \$855,000 over the 50-year period of analysis or \$14.2 million in present worth equivalent values.

Table 17 Distribution of FEMA-Purchased Structures by Floodplain Post Tropical Storm Allison, June, 2001					
Percent Annual Exceedance					Cumulative
Probability Floodplain			Number	Percent	Percent
	50		0	0%	0%
	20		16	13%	13%
	10		13	11%	24%
	4		22	18%	43%
	2		30	25%	68%
	1		9	8%	76%
	0.4		13	11%	87%
	0.2		16	13%	100%
	Total		119	100%	

The removal of 119 damageable properties from the 0.2 percent annual exceedance floodplain of the main stem of Greens Bayou reduced overall damages in the with-project condition by \$315,000 on an average annual basis and reduced the benefits attributable to the Federal project by 0.3 percent. By reducing the benefits attributable to the Federal project, the BCR of the Recommended Plan held steady at 1.61. Neither of these actions compromises the benefits derived from the Federal project. The Cutten Road Basin actually augments the performance of the Federal project by further reducing damages.

4.6 DESCRIPTION OF THE RECOMMENDED PLAN

4.6.1 Plan Components

The Recommended Plan includes two features (Figure 5). The first improvement is reconstructing and recontouring a portion of channel. The channel conveyance improvements are proposed as follows:

- ♦ From Station 1869+41.72 to Station 1941+00 will be trapezoidal with a 60-foot bottom width, 1V:3H side slopes and a meandering low flow pilot channel 1 foot below the channel flow line.
- ♦ From Station 1943+00 to Station 1954+00 will be trapezoidal with a 60-foot bottom width, 1V:3H side slopes, a 12.0' wide bench 6 feet above the channel flow line on the south bank and a meandering low flow pilot channel 1 foot in depth below the required channel flow line.
- ♦ From Station 1956+00 to 1965+00 will be trapezoidal with a 60-foot bottom width, 1V:3H side slopes on the north bank, 1V:4H side slopes and a 12-foot bench on the south bank 6 feet above the channel flow line and a meandering low flow pilot channel 1 foot below the required channel flow line.
- ♦ From Station 1967+00 to Station 1985+00 will be trapezoidal with a 60-foot bottom width, 1V:3H on the north bank, 1V:4H side slopes and a 12-foot wide bench on the south bank 4 feet above the channel flow line and a meandering low flow pilot channel 1 foot below the required channel flow line.
- ♦ From Station 1989+00 to Station 2001+00 will be trapezoidal with a 60.0' bottom width, 1V:3H side slopes, a 12-foot wide bench 6 feet above the channel flow line on the south bank and a meandering low flow pilot channel 1-foot in depth below the required channel flow line.
- ♦ The proposed channel from Station 2003+00 to Station 2019+50 will be trapezoidal with a 60' bottom width, 1V:4H side slopes, a 12-foot wide bench 4 feet above the channel flow line on the south bank and a meandering low flow pilot channel 1-foot in depth below the required channel flow line.
- ♦ From Station 2021+50 to Station 2057+34.07 will be trapezoidal with a 60' bottom width and 1V:3H side slopes.

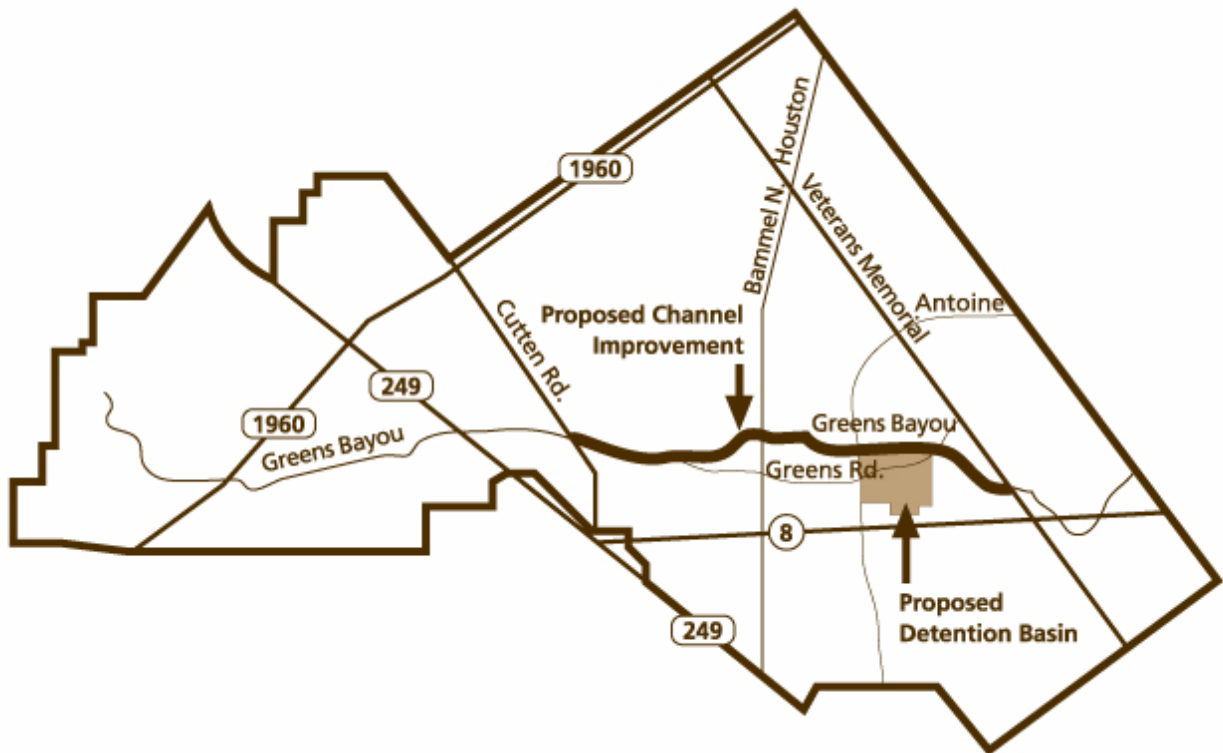


Figure 5
Recommended Plan

The alignment of the proposed channel follows the existing channel in order to minimize excavation. Excavation will be on one side only where possible. In areas where the proposed top of cut reduces the existing top of bank width, the channel was shifted to the side with no real estate improvements. Cross-sections of the proposed channel improvements are shown in Figure 6. Further channel profiles and sections are shown in the Engineering Appendix.

The second feature of the proposed plan is the construction of a 108-acre stormwater detention basin in the vicinity of West Greens Road on a 138-acre site owned by the HCFCFCD. The basin site consists of the 30 acres on the immediate south overbank of Greens Bayou and 78 acres farther south and across West Greens Road. Four 10X10-foot concrete box culverts through West Greens Road connect the two detention basin compartments. The resulting basin's side channel weir is approximately 260 feet long and was modeled approximately 1,000 feet upstream of the West Greens Road bridge. The weir is located between Stations 1918+89 and 1916+39 of Greens Bayou. The weir crest will be located on the sloping bank of the bayou. The side slopes of the weir will extend up to the natural top-of-banks of Greens Bayou to an elevation of about 106 – 108 feet. A 45-foot horizontal concrete apron at elevation 91 feet is recommended to dissipate the hydraulic jump created from the side-channel weir overflow discharge into the basin. Riprap is recommended for about 10 feet extending from the terminus to accommodate flow velocities to less than 6-feet/sec. The side weir of the Federal basin allows basin storage to recede closely with Greens Bayou flood stages. However, for the detention basin to drain when

Figure 6 -- Channel Section

side-channel weir, three, one-way 3-foot diameter reinforced concrete pipes are recommended to drain the remaining flood storage. This allows the basin to recover its flood storage capacity as quickly as possible.

As authorized by WRDA 90 and stated in the 1988 Buffalo Bayou and Tributaries report, this plan meets environmental objectives by including the following features:

- ♦ Environmental features include planting 3,000 native trees and shrubs along the banks of the channel and detention basin, grading the perimeter of the basin in a curvilinear fashion emulating a more natural landscape.
- ♦ The centerline of the channel will be constructed slightly recessed establishing a pilot channel that will meander within the 60-foot bottom template of the channel. The side slopes of the channel will be enhanced through the addition of flood benches in the normal 3 to 1 sloped channel sides.
- ♦ Environmental preservation techniques such as preserving stands of mature existing pine trees and native shrubs within the detention basin footprint will aid in the recovery of the existing habitat that was displaced from the construction of the basin. In addition, oak trees along the channels ROW will be preserved through alignment modifications.
- ♦ Wetland mitigation will be constructed along the pilot channel and in the detention basin totaling 16.3 acres to compensate for the loss 14.72 acres of wetlands present as the site of the detention basin.

These features are designed to improve the aesthetic and visual attractiveness of the project, as well as provide plantings of woody vegetation and wetland vegetation.

This plan maximizes average annual net excess economic benefits at \$8,071,000 and a BCR of 4.01 at an average annual cost of \$2,684,000. In addition, this plan is the most cost effective and implementable which satisfies the identified planning objectives. Recreation facilities are not proposed as part of the Recommended Plan. However, the project is being proposed to allow for future recreation development.

4.6.2 Real Estate Requirements

The optimized channel enlargement consists of an earthen trapezoidal channel requiring approximately 23.5 acres and extending from Cutten Road to Veteran's Memorial Drive, accompanied by a 108-acre capacity detention basin on a 138 acres tract of land owned in fee by the Non-Federal Sponsor. The Non-Federal sponsor owns 3.6 acres in fee and will furnish approximately 19.85 acres in fee to complete the project.

4.6.3 Economic Summary

The estimated first costs and Operations, Maintenance, Repair, Replacement and Rehabilitation costs have been developed using MCACES. These costs, along with total annual costs, annual benefits, net economic benefits and the BCRs are shown on the following table. These values are based on a 50-year period of economic analysis (Table 18). As the recommended plan was justified on the basis of inundation reduction damages to structures and content, per ER-1105-2-100, Appendix E, other benefit categories were added so that the plan would be comparable with

the authorized plan. These damage categories include damages to roads, vehicles, utilities and other costs associated with flooding. Reference the Economic Appendix, pg. 9 for detailed description of these categories.

Table 18		
Economic Summary of Recommended Plan		
Benefit Category	Average Annual Benefits	Average Annual Benefits
Structures & Contents	\$ 5,203,000	\$ 5,536,000
Roads	\$ 961,000	\$ 1,019,000
Utilities	\$ 113,000	\$ 120,000
Vehicles	\$ 3,636,000	\$ 3,854,000
Other Costs	\$ 213,000	\$ 226,000
Total AAE* NED Benefits	\$10,126,000	\$10,755,000
Cost Category	Cost	Cost
PED	\$ 5,470,000	\$ 5,470,000
Lands and Damages	\$ 5,521,000	\$ 5,589,000
Construction	\$20,910,000	\$21,943,000
Const. Contingency	\$ 4,587,000	\$ 4,776,000
Operation/Maintenance	\$ 4,810,000	\$ 4,710,000
Interest During Construction	\$ 3,885,000	\$ 3,814,000
Total NED Cost	\$45,183,000	\$46,302,000
AAE Total NED Cost	\$ 2,718,000	\$ 2,685,000
AAE Net Excess Benefits	\$ 7,408,000	\$ 8,070,000
BCR	3.73	4.01
Price Level - Interest Rate	Oct 2001 - 5-5/8%	Oct 2004 – 5-3/8%

**Average Annual Equivalent (AAE)*

4.7 Comparison of Authorized and Recommended Plans

The description of the authorized project as stated in Section 1 has not changed since the initiation of this GRR study. The project's purpose and local cooperation requirements have not changed since authorization.

The Authorized Plan projected consisted of 14 miles of vegetation clearing in the lower reach, 25 miles of channel enlargement, four detention basins, tree and shrub plantings, and recreation features. The Recommended Plan is identified as the 60-foot-wide channel segment from Veteran's Memorial Drive to Cutten Road (approximately 3.62 miles), coupled with a 108-acre detention basin located downstream of the channel segment at West Greens Road. Costs and

benefits for the Authorized Plan are greater due to the scale of the project. Net excess benefits of the Authorized Plan are greater, as well. However, the BCR for the Recommended Plan is 3.77 compared with 2.69 for the Authorized Plan. Benefits and costs for the Authorized Plan and the Recommended Plan are compared in Table 19.

Even though the Authorized Plan produces greater net excess benefits, the USACE and the Non-Federal Sponsor recommend the more environmentally sensitive, albeit smaller scale Recommended Plan of the 60-foot bottom width channel from stream station 187199 to stream station 206328 and the 108-acre detention basin.

Table 19					
Comparison of Authorized Project and Recommended Plan (Flood Control)					
	Authorized Plan (1)	Last Presented to Congress (2)	Last Presented Updated	Recommended Plan	Recommended Plan
First Cost	\$118,035,000	\$274,320,000	\$279,806,000	\$36,488,000	\$37,778,000
Benefits	\$32,205,000	\$63,624,000	\$44,534,000	\$10,126,000	\$10,755,000
Net Excess Benefits	\$20,219,000	\$39,580,000	\$27,704,000	\$ 7,440,000	\$ 8,070,000
BCR	2.69	2.65	2.65	3.73	4.01
Price Level	Jan 1988	Oct 2000	Oct 2001	Oct 2001	Oct 2004
Interest Rate	8.625%	8.625%	5.625%	5.625%	5.375%

**Benefits and Costs Dollars are Average Annual Equivalents (AAE)*

(1)Data regarding the authorized project is from Buffalo Bayou and Tributaries, Texas Feasibility Report (Flood Damage Prevention), Volume 1 Main Report, May 1988.

(2)Information from Justification Sheet, 2 Feb 2004 and includes recreation

4.8 IMPLEMENTATION REQUIREMENTS

4.8.1. Institutional Requirements

The Recommended Plan is a smaller version of the Authorized Plan and therefore no reauthorization is required. After project plan approval, the project would be eligible for construction funding. The project would be considered for inclusion in the President's budget based on national priorities, magnitude of the Federal commitment, economic and environmental feasibility, level of local support, willingness of the Non-Federal Sponsor to fund its share of the project cost and the budget constraints that may exist at the time of funding. A project

cooperation agreement (PCA), defining the Federal and non-Federal responsibilities for implementing, operating and maintaining the project will be negotiated. The USACE would officially request the sponsor to acquire the necessary real estate immediately after the signing of the PCA. Once Congress appropriates Federal construction funds, advertisement of the construction contract would follow the certification of the real estate. The final acceptance and transfer of the project to the Non-Federal sponsor would follow the delivery of an operations and maintenance (O&M) manual and as-built drawings. The estimated schedule for project implementation is shown in Table 20.

Table 20		
CONSTRUCTION SCHEDULE		
CONTRACT NO.	START	FINISH
No. 1 Detention Basins	Nov 05	Nov 06
No. 2 Channel Improvements	Nov 06	Feb 08
No. 3 Detention Basin Environmental Features	Dec 07	Aug 08
No. 4 Channel Improvements	Aug 08	Oct 09

4.8.2 Credit Provisions

Section 350 of WRDA 1996 states that the non-Federal interests for the project for flood control, Buffalo Bayou and tributaries, may be reimbursed or credited of up to \$5,000,000 for work performed by the non-Federal interest at specified, authorized projects if such work is compatible with the authorized project. Draft guidance suggests that credit or reimbursement provided under this provision shall follow the same policies and procedures used under Section 215 of the Flood Control Act of 1968, as amended, as contained in ER 1165-2-18. Additionally, if a non-Federal sponsor elects to undertake work pursuant to Section 211 of WRDA 1996, where applicable, no part of that work will be eligible for credit or reimbursement pursuant to Section 350 of WRDA 1996 or Section 215 of the Flood Control Act of 1968. At this time, the HCFCD does not plan any Section 350 request. Table 21 shows the cost apportionment and fully funded cost estimate for the Recommended Plan.

4.8.3 Views of Non-Federal sponsors and any other agencies having implementation responsibilities.

The HCFCD has expressed the desire for implementing the project and sponsoring project construction, if USACE project implementation is delayed, in accordance with the items of local cooperation that are set forth in the recommendations section of this report. The financial

analysis indicates that the Non-Federal Sponsor is financially capable of participating in the recommend plan, the 60-foot channel with 108-acre detention basin.

The HCFCD would also like to allow the contractor for excavation to have the option of disposing of the material on their own, subject to USACE approval. This could offer the potential for a reduced excavation price.

Table 21			
PROJECT COST			
		FIRST COST	FULLY FUNDED COST
Cost		MCACES	MCACES
Account	Item Description	(1 Oct 04 Price Level)	(1 Oct 04 Price Level)
<u>Federal Flood Control Cost</u>			
Charges through 30 Nov 2003		\$ 5,230,000	\$ 5,230,000
GRR		240,000	240,000
01	Lands & Damages	39,000	42,000
09	Channels & Canals	5,027,000	5,422,000
15	Flood Control & Diver Str	13,071,000	13,755,000
30	Engineering & Design	1,565,000	1,758,000
31	Constct Mngt	5,031,000	5,977,000
Federal Flood Control		\$ 30,203,000	\$ 32,424,000
<u>Non-Federal Flood Control Cost</u>			
01	Lands & Damages	\$ 6,945,000	\$ 7,333,000
02	Relocations	630,000	691,000
Non-Federal Flood Control		\$ 7,575,000	\$ 8,024,000
Total Flood Control		\$ 37,778,000	\$ 40,448,000
<u>Cost Apportionment Flood Control</u>			
Federal Flood Control		\$ 30,203,000	\$ 32,424,000
Less Non-Federal 5% Cash Contribution		1,889,000	2,022,000
TOTAL FEDERAL FLOOD CONTROL		\$ 28,314,000	\$ 30,402,000
Non-Federal Flood Control		\$ 7,575,000	\$ 8,024,000
Non-Federal 5% Cash Contribution		1,889,000	2,022,000
TOTAL NON-FEDERAL FLOOD CONTROL		\$ 9,464,000	\$ 10,046,000
Total Flood Control		\$ 37,778,000	\$ 40,448,000

5.0 AFFECTED ENVIRONMENT

5.1 GENERAL DESCRIPTION

The Greens Bayou project area consists of about 210 square miles in the north-central and eastern part of Houston and Harris County, Texas. The area is part of the Buffalo Bayou and tributaries watershed that drains much of the urbanized area of Houston and surrounding suburban communities. Greens Bayou lies approximately 10 miles north and east of the central business district of Houston. The Cypress Creek and San Jacinto River watersheds adjoin the Greens Bayou watershed to the north and Carpenters Bayou adjoins the bayou to the east. The bayou flows generally east from its headwaters just west of Farm-to-Market Highway 1960 for a distance of about 23 miles and then turns south for another 19 miles to its junction with Buffalo Bayou and the Houston Ship Channel. The Greens Bayou watershed is situated in the coastal lowland subdivision of the West Gulf Coastal Plain and cuts the fluvial and deltaic deposits of the Pleistocene Beaumont and Lissie Formations (Wheeler, 1976). The watershed is relatively long and narrow with a maximum width of about 8 miles and average width of less than 4 miles. The land in the watershed slopes gently in an easterly and southerly direction. Elevations within the watershed area range from about 8 feet at the mouth of the bayou to 125 feet near the headwaters. Elevations are referenced to the NGVD with the 1987 vertical adjustment.

The watershed is situated within a humid region of southeast Texas, which is influenced by the Gulf of Mexico. The area is characterized by long, warm summers and short, mild winters. The area is subject to intense local thunderstorms of short duration, general storms that extend over a period of several days, and torrential rainfall associated with hurricanes and other tropical disturbances that periodically cause flooding of local streams.

The bayou has been channelized in an effort to control the flooding that frequently results from severe storm events. The bayou contains an existing federally-constructed navigation channel in the lowermost three miles. As part of the Texas coastal plain, the watershed is relatively flat and devoid of topographic features with moderate to slow surface drainage. Greens Bayou provides a drainage outlet for a number of lateral storm water runoff and on-channel drainage systems within its basin. The major tributaries of the bayou are Garners and Halls Bayou. The recommended plan covered in this report is situated in the watershed in the upper reaches of the bayou above Veterans Memorial Drive (mile 35.4).

The project area has experienced a growth in urbanization in the past three decades. The population in the watershed increased from about 157,600 in 1980 to about 397,000 in 2000. The Greens Bayou watershed contains extensive urbanization with residential, commercial and industrial development. The availability of developable land and the proximity of Houston Bush Intercontinental Airport contribute to expectations for continued substantial growth within the watershed. The watershed has attracted high value urban development over the past several decades. Residential areas are distributed along most of the length of Greens Bayou in lower, middle, and upper reaches. Commercial and retail facilities are located throughout the watershed and along the major traffic arteries. Industrial facilities are located throughout the watershed and in the Houston Ship Channel vicinity.

5.2 BIOLOGICAL RESOURCES

5.2.1 Vegetation

The Greens Bayou watershed is situated within the Gulf Prairies and Marshes ecological area of Texas (Gould, 1975). Within the upper Greens Bayou project area, the principal land uses are residential and commercial development and agricultural activities and much of the native vegetation has been displaced through these activities. Habitat types in the upper bayou area include developed urban lands, disturbed prairies, agricultural lands, and wooded areas. Urban lands include man-made or man-modified conditions such as residential housing, commercial and retail buildings, and maintained, undeveloped lots. Developed urban areas contain a mix of ornamental and native plant vegetation. Open agricultural lands are used primarily as pastures for grazing or hay production. Disturbed prairies include vegetation consisting of a diversity of grassland species and invasive shrubs. The wooded areas in the project area are a mix of invasive species, remnants of native vegetation and ornamental plants. Urban development has reduced most of the native habitat in the project area to fragmented and isolated remains.

- Channel. Greens Bayou has been channelized and straightened throughout much of its length. The Greens Bayou reach proposed for modification upstream of Veterans Memorial Drive is a grass-lined channel supporting mostly Johnson grass (*Sorghum halepense*), bermuda grass (*Cynodon dactylon*) and giant ragweed (*Ambrosia trifida*) with an occasional small black willow (*Salix nigra*) on the banks. The bayou rights-of-way (ROW) are regularly mowed and maintained by HCFCD.
- Detention Basin. The proposed detention for the project would occur in two detention basin cells along West Greens Road south of the bayou that have been disturbed by agricultural and urbanization activities. The detention cell south of West Greens Road is a 78-acre area that has been used as a pasture and is vegetated with invasive grasses and shrubs such as Johnson grass, western ragweed (*Ambrosia psilostachya*), baccharis (*Baccharis halimifolia*), yaupon (*Ilex vomitoria*), huisache (*Acacia sp.*), honeysuckle (*Lonicera sp.*), goldenrod (*Solidago sp.*), dewberry (*Rubus trivialis*) and poison ivy (*Toxicodendron radicans*). Patches of second-growth trees exist in parts of the tract and include Chinese tallow (*Sapium sebiferum*), sweetgum (*Liquidambar styraciflua*), hackberry (*Celtis laevigata*) and pine (*Pinus taeda*). Commercial development has recently occurred along Antoine Road immediately adjacent to the southwest side of the cell. Residential development has also occurred adjacent to the site. A total of about 2.3 acres of wetlands in small scattered areas were identified within this proposed cell. The wetland areas are in disturbed areas of the cell and support sedge, rush and Chinese tallow saplings and are generally considered to be of low-value for wildlife habitat. This proposed detention cell overall has limited native wildlife value because of past clearing and land disturbances in the area and proximity to surrounding urban development.

The proposed detention cells will be located on a 108-acre area has been disturbed by past clearing of vegetation for development activities. The area is currently vegetated with invasive grasses, shrubs, and undergrowth and contains areas of second-growth pine, sweetgum,

hackberry and tallow. An excavated pond estimated to be less than 0.05 acre is situated along West Greens Road adjacent to the proposed detention cell will be avoided by the project detention basin. Wetlands totaling 14.72 acres were identified within this proposed footprint. The wetlands were primarily in two areas that supported herbaceous species such as sedge, rushes, small woody shrubs and green ash, sweetgum, and tallow. These areas are considered providing limited value as wildlife habitat. The proposed overall cell has low native wildlife value because of past land disturbance at the site and proximity to development.

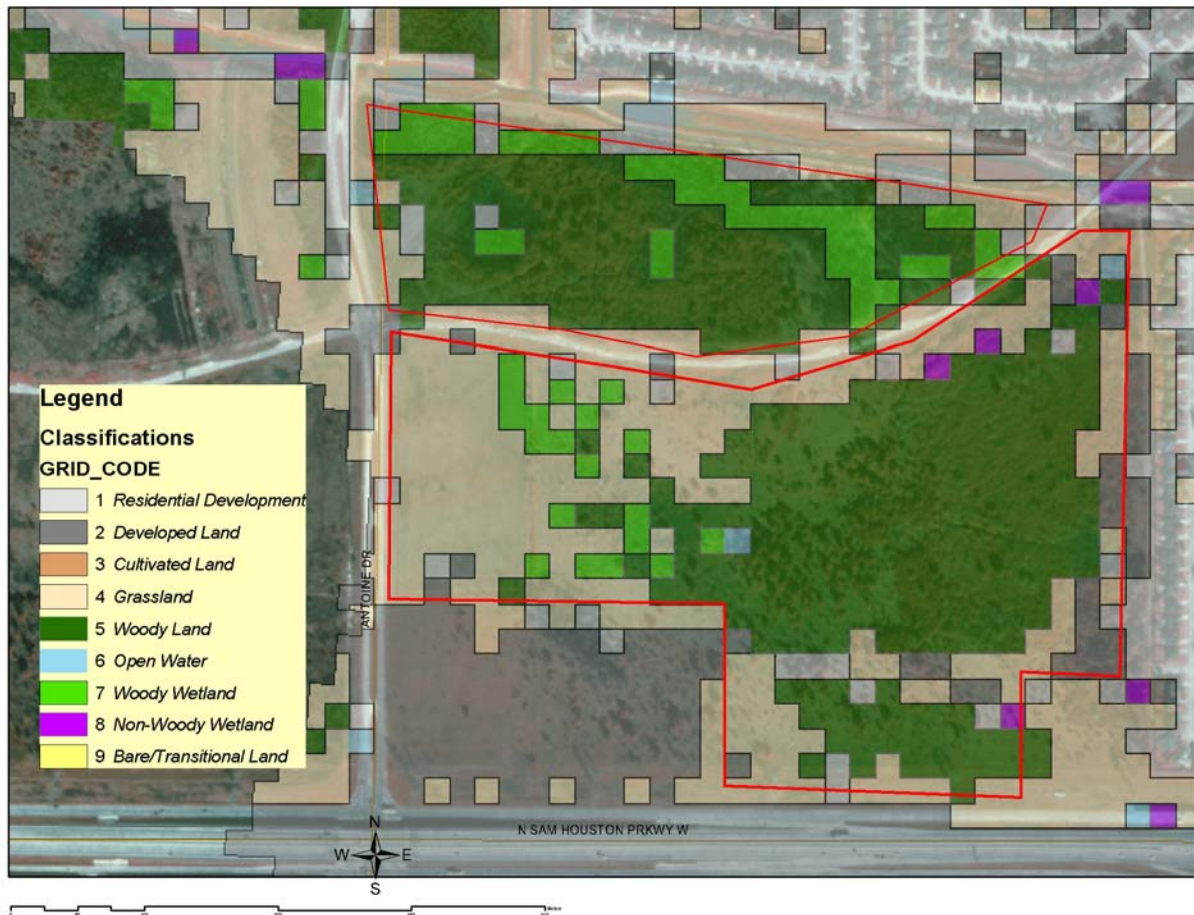


Figure 7. Detention Basin Vegetation Classification.

5.2.2 Wildlife Resources

Wildlife resources in the upper Greens Bayou area are limited because of urban development and other disturbances and consist of species adapted to an urban setting. Common bird species in the project area include the mockingbird (*Mimus polyglottos*), mourning dove (*Zenaidura macroura*), starling (*Sturnus vulgaris*), bluejay (*Cyanocitta cristata*), woodpeckers of several species, cardinal (*Richmondia cardinalis*), house sparrow (*Passer domesticus*) and boat-tailed grackle (*Cassidix mexicanus*). The trees and ornamental shrubs in the urban habitat provide food and shelter for birds. Small to medium-sized mammals potentially in the area are the raccoon

(*Procyon lotor*), opossum (*Didelphis virginiana*), cottontail rabbit (*Sylvilagus floridanus*), striped skunk (*Mephitis mephitis*), armadillo (*Dasypus novemcinctus*), and rodents including white-footed mouse (*Peromyscus leucopus*) and the house mouse (*Mus musculus*). Amphibians in the project area include frogs and several species of toads including gulf coast toad (*Bufo valliceps*), Woodhouse's toad (*Bufo woodhousei*), and Eastern spadefoot toad (*Scaphiopus holbrooki*). Reptiles which may be encountered in the area include the green anole (*Anolis carolinensis*), ground skink (*Leiopisma laterale*), eastern garter snake (*Thamnophis sirtalis*), Texas rat snake (*Elaphe obsoleta lindheimeri*), red-eared turtle (*Chrysemys scripta elegans*), Texas slider (*Chrysemys concinna texana*) and three-toed box turtle (*Terrapene carolina triunguis*).

5.2.3 Aquatic Resources

Greens Bayou provides poor aquatic habitat in the upper bayou area. Flow within the bayou is primarily derived from urban rainfall runoff and wastewater treatment plant effluent. The limited aquatic habitat of the bayou is probably attributed to sources of streamflow, fluctuating water levels, high nutrient levels and algal growth in the bayou, shallow water depths, and high water temperatures. Common fish species found in the upper reach of the bayou are mosquito fish (*Gambusia affinis*), green sunfish (*Lepomis cyanellus*), sailfin molly (*Poecilia latipinna*), and sheepshead minnow (*Cyprinodon varieptus*). Invertebrates such as gastropods, insect larvae, and several species of crayfish also can tolerate the fluctuating water levels and nutrient overload. A significant sport fishery does not occur in the upper bayou reaches since species diversity and abundance of game fish are kept low by fluctuating water levels and limited water quality.

5.2.4 Placement Areas

Excavated materials removed during construction of the channel modifications and detention basins will be hauled away from the construction area and placed in upland sites or allowed to be disposed at alternate sites by the contractor. Disposal of excavated material by a contractor will be subject to HCFCD approval and all applicable NEPA documentation and environmental coordination will be required. The potential placement areas (PA) would be generally located on open urban sites and cleared grasslands and pasture in the project vicinity. The following describes the biological conditions of proposed PA (Figure 8).

PA 1. This site (156 acres) is an open land tract located south of the bayou and near the North Sam Houston Parkway Beltway 8. The site is open grassland used for livestock grazing purposes and provides low quality wildlife habitat.

PA 2. This site (225 acres) is situated south of the bayou and adjacent to the North Sam Houston Parkway Beltway 8. The site has been disturbed by past land clearing activities and is an open grassland field with some areas of tree growth. Trees are primarily Chinese tallow with occasional hackberry and a significant amount of McCartney rose. Chinese tallow and McCartney rose are invasive species. The site has low quality habitat for wildlife.



Figure 8. Placement Sites

5.3 THREATENED AND ENDANGERED SPECIES

5.3.1 The USFWS has provided an updated list of federally-protected threatened and endangered species in the project area. The USFWS identified the following threatened or endangered species in Table 22 that may occur in the project area:

Table 22
Federally Listed Threatened or Endangered Species

COMMON NAME	SCIENTIFIC NAME	LISTING STATUS
BIRDS		
Bald Eagle	<i>Haliaeetus leucocephalus</i>	Threatened
VASCULAR PLANTS		
Texas Prairie Dawn	<i>Hymenoxys texana</i>	Endangered

Source: US Fish & Wildlife Service (2003)

5.3.2 The TPWD has identified additional species considered threatened or endangered as potentially occurring in Harris County (Table 23). This list also includes other state species of concern. State-listed threatened and endangered species are not protected under the Endangered Species Act, nor are species of concern, which are species for which there is some information showing evidence of vulnerability, but not enough data to support a Federal listing. Only those species listed as endangered or threatened by the USFWS or NMFS are afforded complete Federal protection.

Table 23
Texas Parks and Wildlife Department
Texas Annotated County List of Rare Species for Harris County

COMMON NAME	SCIENTIFIC NAME	LISTING STATUS
AMPHIBIANS		
Houston Toad	<i>Bufo houstonensis</i>	Endangered
BIRDS		
American Peregrine Falcon	<i>Falco peregrinus anatum</i>	Endangered
Arctic Peregrine Falcon	<i>Falco peregrinus tundrius</i>	Threatened
Attwater's Greater Prairie Chicken	<i>Tympanuchus cupido attwateri</i>	Endangered
Bald Eagle	<i>Haliaeetus leucocephalus</i>	Threatened
Brown Pelican	<i>Pelecanus occidentalis</i>	Endangered
Henslow's Sparrow	<i>Ammodramus henslowii</i>	Species of Concern
Black Rail	<i>Laterallus jamaicensis</i>	Species of Concern
Piping Plover	<i>Charadrius melodus</i>	Threatened
Reddish Egret	<i>Egretta rufescens</i>	Threatened
Snowy Plover	<i>Charadrius alexandrinus</i>	Species of Concern
Sooty Tern	<i>Sterna fuscata</i>	Threatened

COMMON NAME	SCIENTIFIC NAME	LISTING STATUS
Swallow-tailed Kite	<i>Elanoides forficatus</i>	Threatened
White-faced Ibis	<i>Plegadis chihi</i>	Threatened
Wood Stork	<i>Mycteria Americana</i>	Threatened
MAMMALS		
Black Bear	<i>Ursus americanus</i>	Threatened
Louisianan Black Bear	<i>Ursus americanus luteolus</i>	Threatened
Plains Spotted Skunk	<i>Spilogale putorius interrupta</i>	Species of Concern
Rafinesque's Big-eared Bat	<i>Corynorhinus rafinesquii</i>	Threatened
Red Wolf	<i>Canis rufus</i>	Endangered
Southeastern Myotis Bat	<i>Myotis austroriparius</i>	Species of Concern
REPTILES		
Alligator Snapping Turtle	<i>Macrochelys temminckii</i>	Threatened
Atlantic Hawksbill Sea Turtle	<i>Eretmochelys imbricata</i>	Endangered
Green Sea Turtle	<i>Chelonia mydas</i>	Threatened
Gulf Saltmarsh Snake	<i>Nerodia clarkia</i>	Species of Concern
Kemp's Ridley Sea Turtle	<i>Lepidochelys kempii</i>	Endangered
Leatherback Sea Turtle	<i>Dermochelys coriacea</i>	Endangered
Loggerhead Sea Turtle	<i>Caretta caretta</i>	Threatened
Northern Scarlet Snake	<i>Cemophora coccinea copei</i>	Threatened
Scarlet Snake	<i>Cemophora coccinea</i>	Threatened
Texas Diamondback Terrapin	<i>Malaclemys terrapin littoralis</i>	Species of Concern
Texas Horned Lizard	<i>Phrynosoma cornutum</i>	Threatened
Timber/Canebrake Rattlesnake	<i>Crotalus horridus</i>	Threatened
VASCULAR PLANTS		
Corkwood	<i>Leitneria floridana</i>	Species of Concern
Scarlet Catchfly	<i>Silene subciliata</i>	Species of Concern

Source: TPWD (2002)

5.4 WATER QUALITY

Water quality conditions in the Greens Bayou area were discussed in the FEIS (USACE, 1988). The section of Greens Bayou above tidal limits has been established as a stream segment (segment 1016) by the TCEQ (TNRCC, 1996). The TCEQ has classified Greens Bayou as water quality limited. Stream flow in the bayou is supported primarily by the T.H. Wharton power plant discharges at the headwaters, effluent from wastewater treatment plant outfalls located along its entire length and rainfall. Effluents contribute large quantities of oxygen demanding materials and nutrients that cause a depression of dissolved oxygen concentrations in the bayou. Advanced waste treatment for point source water discharges is required to meet water quality standards. The stream does not meet contact recreation use due to elevated fecal coliform bacteria levels and has limited quality aquatic life use potential (Houston-Galveston Area Council (H-GAC), 1996).

An intensive stream survey conducted in August 1999 by H-GAC found dissolved oxygen concentrations near saturation at all stations except near the headwaters where the bayou was very shallow and overgrown with vascular plants. Because the only flow in the bayou during dry periods is treated wastewater effluent, nutrient concentrations were elevated, but there was no indication of extreme diurnal variations in dissolved oxygen during the survey. Results of trace metal monitoring (copper, lead, and mercury) performed at weekly intervals during the survey indicated all parameters were well below chronic criteria. A biological assessment conducted for this survey confirmed that the bayou had a limited aquatic life use potential, primarily because of its limited diversity of habitat types (H-GAC, 2004).

5.5 HISTORIC PROPERTIES

Historical research and archeological surveys of the upper Greens Bayou project indicate that the area was not intensively utilized by prehistoric or historic-era peoples until the early twentieth century (Howard, Freeman and Bowsman, 1991; Moore, 1991; Prikryl and Moore, 1997; and Gadus and Moss, 1998). Prehistoric occupation of the Greens Bayou watershed appears to have been focused in the downstream reach close to Buffalo Bayou. This is reflective of the typical prehistoric settlement pattern for inland Harris County in which residential base camps tend to be located near the intersections of large, permanent watercourses. One large, residential camp, the Dyersdale site (41HR60), has been reported on Greens Bayou well downstream of the current project area. It was an extensive terrace site with occupations in the Archaic and Ceramic periods. Small, short-term campsites are widespread along the entire reach of the bayou. These sites are most commonly found in or immediately adjacent to the floodplain, and are often associated with natural, floodplain mounds. Dates and occupation spans for the short-term sites are often difficult to determine because of the paucity of artifacts, but they are believed to range in age from the Late Archaic through the Ceramic periods.

In general, the potential for prehistoric sites in the project area is believed to be very low based upon the results of the previous surveys along the bayou itself and other surveys of inland Harris County near Cypress Creek and Buffalo Bayou. While site density in the floodplain of Greens Bayou has been determined to be extremely low, site density in inland areas is almost zero. Surveys investigating upland zones in the upper Green's Bayou watershed have found that areas

removed from the bayou itself have no recorded prehistoric sites farther than approximately 1,500 feet from the stream.

Sparse prehistoric usage of the upper Greens Bayou area is mirrored by historic-era settlement patterns. Archival research for the entire Greens Bayou floodplain indicates that the upper reaches of the bayou have never been an important waterway for trade or transportation. During the first wave of permanent settlement of the region in the 1830's, settlements remained primarily in the southern part of Harris County and were tied to the larger watercourses in the region.

The Greens Bayou area saw no permanent settlement until the late 19th century when agricultural, lumbering, and milling enterprises were established along the lower part of the bayou. Little economic activity was present in the upper Greens Bayou area at that time. Transportation routes largely bypassed the area until after the Civil War when a railroad was built through upper Harris County connecting Houston to Austin. A few scattered truck and stock farmers ventured into the area in the last decades of the 19th century, settling primarily near established roads. At the turn of the century, real estate promotions by the railroads and land speculators brought immigrants from the Midwest and other countries into early agricultural subdivisions with farm plots averaging 10 acres in size. Promotion of the Greens Bayou area peaked around 1910-15; however these promotions focused on the eastern portion of the upper Greens Bayou area and did not touch the current project area. Limited growth and development of the upper Greens Bayou project area in the early 20th century is demonstrated by the lack of east-west roads on pre-1920 U.S. Geological Survey (USGS) maps. All major and minor public roads stopped at Veterans Memorial Drive (formerly Stuebner-Airline Road). As late as 1954, USGS maps indicate no internal roads in the project area. Aerial maps from 1955 define the area as rural; with farming and pastureland the sole land use. Based on this information, the potential for significant historic sites in the area is also considered to be low.

Disturbances to the project area associated with channelization, agriculture, residential, commercial and oil field development are abundant. Channelization of Greens Bayou began in the early part of the 20th century, even in the upper and western portions of the Greens Bayou watershed. Portions of its tributaries contained levees constructed in conjunction with farming and ranch development by 1920. Several canals had been excavated for irrigation or drainage. Drainage and irrigation ditch construction encouraged agricultural activities that disturbed areas distant from the bayou and ditches themselves. The extent of disturbance and development has had a significant impact on site preservation in the project area.

5.6 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTES (HTRW)

A baseline HTRW assessment was conducted by the USACE Tulsa District from mile 0 to mile 39.2 for the Greens Bayou Flood Damage Reduction project to evaluate the relative risks of encountering solid or hazardous wastes within the project area (CE, 1993). This information was updated for the proposed project and PAs in the upper watershed and includes oil and gas wells and pipelines (PBS&J, 1999). The assessment methodology included site visits and review of land use changes in the bayou area from historical aerial photographs, interviews with regulatory agency personnel, reviews of records from regulatory agencies, and review of physical and

geological data. An update was performed again in 2004 utilizing EPA and TCEQ database websites.

Aerial photography for the project vicinity covering time periods from the 1940's to 1990's was reviewed for historical land use. Prior to 1940, the majority of the area was vacant, undeveloped land. The area contained scattered single-family residences, some commercial buildings, and no industrial activity. Very limited oil/gas exploration activities were evident within the project area. In the 1950's and 60's, the majority of the project area lands remained unchanged. Some channel modifications of the bayou were conducted in the area. There was further residential development in the northeast and southeast portions of the study area, west of Veterans Memorial Boulevard and north of the present day Sam Houston Parkway. The T.H. Wharton Electric Generating Station, surface impoundments and above ground storage tanks were constructed in the southwest portion of the project area south of SH 249. Single-family residences and commercial buildings were constructed as well along and west of Bammel-North Houston Road. Two pipeline easements crossed the area. During the 1970's, the project area had undergone considerable development, primarily single-family residential subdivisions and further commercial development along major roads. The project area continued to experience further residential subdivision and commercial development during the 1980's and 90's. The Sam Houston Parkway (Beltway 8) was constructed in the Greens Bayou area during these periods.

A search of regulatory agency databases was conducted to identify HTRW sites in the project area. The databases searched included the National Priority List (NPL); Comprehensive "Environmental Response Compensation and Liability Information System Database (CERCLIS); No Further Remedial Action Planned Database (NFRAP); Resource Conservation and Recovery Information System (RCRA) – Treatment, Storage, or Disposal Database (TSD); Corrective Action Database (CORRACT); RERA – Generators Database (RECR-G); Emergency Response Notification System Database (ENS); Texas Voluntary Cleanup Program (TXVCP); Texas State Superfund List (TXSSF); TNRCC Solid Waste Facilities Database (TXLF); Leaking Underground Storage Tank Database (TXLUST); Texas Underground Storage Tanks Database (TXAST); and the Texas Spills List (TXSPILL).

The agency file review identified 23 facilities registered with various State and Federal agencies within the project area. The facilities include one NFRAP site, six RCRA Generators, four emergency response/spill incidents, seven LUST sites, sixteen facilities with USTs, and two AST sites. None of the incidents at these facilities will impact the project. No NPL, RCRA-TSD, CERCLIS, SSF, TXVCP, CORRACT, or TXLF sites were identified.

The Reliant Energy (formerly Houston Lighting and Power Company) electric generating station located in the upper watershed area is listed by the EPA as a NFRAP site. No other NFRAP sites were identified within the project area. The RCRA generators located in the project area had no violations recorded. Regulatory files have identified 47 registered underground storage tanks (UST) associated with facilities in the area. Twenty-seven of the registered USTs have been removed from the ground or abandoned in-place. Three incidents involving emergency responses have occurred in the recent past at the electric generating station but the releases were contained and remediated.

Seven facilities with a leaking underground storage tank were identified in the project area. The TCEQ issued final concurrence and closed the case at four of the sites and the remaining sites have cases pending with the TCEQ. The facilities were located away from Greens Bayou and have had no apparent threats or impacts to nearby receptors.

Two facilities identified within the study area have registered Aboveground Storage Tanks (ASTs). The Houston Shell and Concrete and Alsay facilities have ASTs utilized for storage of diesel fuel. The AST's are currently in use and are situated within concrete or earthen-diked secondary containment features.

A spill incident was previously reported within the project area at the Best Pak Disposal, Inc. facility near Greens Bayou and involved a small release of organic waste paint.

A review of Railroad Commission of Texas (RCT) files was conducted to locate and map recorded oil and gas well drilling activities and locate pipelines traversing the study area. Two pipelines and twenty-one recorded oil and gas wells were identified within the project area. A 14-inch diameter pipeline is operated by the Mid-America Pipeline Company and is listed as containing hazardous liquid. A 30-inch natural gas pipeline is operated by Midcon Texas Pipeline Operator. The current status of this pipeline is unknown. Of the recorded oil/gas wells, fourteen of the wells are listed as dry wells, six are listed as gas wells, and one well has not been drilled. Three wells are currently in production in the vicinity of the project but pose no environmental threat.

5.7 AIR AND NOISE QUALITY

5.7.1 Air Quality

Ambient air quality is monitored in the Houston area by a network of monitoring stations maintained by the City of Houston and the TCEQ. To comply with the 1970 Clean Air Act (CAA) and the 1990 Amendments, the EPA has promulgated National Ambient Air Quality Standards (NAAQS) for the protection of the public health and welfare with the allowance of an adequate margin of safety. The EPA has set NAAQS for six criteria pollutants – lead, sulfur dioxide, nitrogen dioxide, carbon dioxide, ozone and particulates. The project is located within the Houston-Galveston Air Quality Control Region District, also referred to as the Houston-Galveston Area (HGA). Air quality data indicate that the HGA counties in the study area are within the air quality standards set by the EPA for five of the six criteria pollutants (TNRCC, 1997). All eight counties of the Gulf Coast State Planning Region (includes Harris, Montgomery, Chambers, Brazoria, Liberty, Galveston, Fort Bend and Waller Counties) exceeded the standards for ozone and are designated by the EPA as nonattainment for ozone. Currently, the HGA is classified as a severe nonattainment area for ozone under the 1-hour National Ambient Air Quality Standard for ozone. However, the U.S. Environmental Protection Agency has recently promulgated an 8-hour ozone standard to replace the 1-hour standard. Based on the 8-hr ozone standard, the HGA will be reclassified to a moderate nonattainment area effective June 15, 2005. In accordance with regulatory requirements, Section 176 of the CAA, known as the General Conformity Rule and Texas Rule, 30 TAC 101.30, respectively, criteria

were established for air quality preservation that apply to Federal actions in areas that are designated as being in non-attainment for any of the criteria pollutants.

5.7.2 Noise

Pursuant to the Noise Control Act of 1972 as amended by the Quiet Communities Act of 1978, the EPA has developed appropriate noise-level guidelines. The EPA generally recognizes an average day-night noise level (Ldn) of less than 50 decibels a-weighting (dBA) (USEPA, 1978) for rural areas and between 55 and 60 dBA for urban areas. Hearing loss could result if the average outdoor noise level is in excess of 70 dBA or more for 24 hours over a 40-year period (USEPA, 1974). Several factors affect response to noise levels, including background level, noise composition, and level fluctuation, time of year, time of day, history of exposure, community tolerance, and individual emotional factors. In general, people are more tolerant of a given noise if the background level is closer to the level of the new noise source. People are more tolerant of noises during daytime than at night when background noise normally diminishes, increase sound awareness. Residents are more tolerant of an activity if it is considered to benefit the economic or social well-being of the community or them individually. Noise levels have a much greater affect on outdoor than indoor activities. The urban nature of the area surrounding Greens Bayou assures that the level of ambient noise is raised above that of a rural setting. Ambient sound levels in the project area are affected by vehicular traffic on local highways and roads, construction activities in the area, and commercial and residential activities. There is also some increase in sound levels associated with air traffic over the area, which has occasional overflights from aircraft arriving or departing local airports.

5.8 RECREATION RESOURCES

A total of 14 public parks with open space and developed facilities exist within the Greens Bayou watershed. Of this total, nine of the parks are 10 acres or less in size. Most of the public parks are located in the watershed downstream of IH-45. The majority of the recreation land in the watershed is contained in Brock Park located in the lower bayou reach. Many of the developed public parks are located adjacent to or near Greens Bayou near residential areas. Some of the public parks have limited recreational facilities. Urban recreation lands are generally in short supply upstream of Veterans Memorial Drive in the project area. There are no public parks in this reach of Greens Bayou. Several residential subdivisions in the upper watershed contain developed recreation common areas for the exclusive use of homeowners. Neighborhood parks are contained in subdivisions in the project vicinity such as Cutten Green, Copper Creek, Ashcreek, and Briar Creek. Private development in these areas includes swimming pools, picnic areas, playgrounds, and trails.

5.9 PRIME AND UNIQUE FARMLANDS

The U.S. Department of Agriculture, Natural Resource Conservation Service (NRCS) was contacted regarding prime and unique farmlands. The Greens Bayou project area in the Houston area is dedicated to urban development and contains no prime and unique farmlands.

5.10 SOCIOECONOMIC RESOURCES

Greens Bayou runs through or is contiguous to portions of the City of Houston, including annexed areas physically separated from the bulk of the city. Other areas of the bayou flow through unincorporated portions of Harris County that are not part of the city.

5.10.1 Development

Growth and development within the Greens Bayou watershed has paralleled that of Houston in general. The Greens Bayou watershed shared in the growth and expansion that was brought about by the Houston area transformation into a national petroleum center, the stimulus of the Houston Ship Channel, and the growth of petrochemical manufacturing, particularly synthetic rubber, associated with the demands of World War II. Following the war, growth in the watershed continued to mirror that of the Houston area. Increased transportation routes, particularly the interstate system, opened many areas up for suburban development expansion. The 1960's saw the arrival of shopping centers, business centers, and light industry. The George Bush Intercontinental Airport provided jobs and a focus for associated industries and businesses. Residential growth in the watershed accompanied these developments and other activities in the area, as housing was required for employees and others. There are large areas of residential and commercial developments and some industrial development that has been completed in the lower and middle watershed between Interstate Highway (IH)-10 and IH-45. Extensive urban development has occurred in the upper watershed upstream of IH-45 and is expected to continue in the future. Land uses in the upper watershed in the project vicinity consist primarily of residential subdivisions, commercial and service facilities, light industrial facilities, undeveloped lands, and agricultural lands.

5.10.2 Demographics

Population and employment are a measure of the growth and development of the watershed. From 1980 to 1990, population in the census tracts within by the Greens Bayou floodplain increased by 24 percent and employment grew by 50 percent. In the 1990 to 2000 decade, the relative growth rates of population increased by 25 percent and employment by 21 percent. The area along Greens Bayou and its watershed is a developing area, comprising one of the newer sections of the metropolitan area. It is reasonable to expect this growth will continue to occur in the foreseeable future.

Population estimates for the year 2000 for the project area (i.e., the without-project 1 percent annual exceedance floodplain) were determined using census blocks whose boundaries were intersected by the floodplain. The total population of all census blocks intersected by the floodplain was about 74,550. The number of persons within each block was multiplied by the percentage of the block within the floodplain. The 2000 population for the Greens Bayou 1 percent annual exceedance floodplain was about 33,200.

The study area contains a diversity of racial types. In 2000 Hispanics accounted for 38 percent of the total study area population, followed by Blacks at 28 percent, non-Hispanic whites at 27 percent and Asians at 6 percent, and others one percent. Hispanics and Blacks are over

represented in the study area in comparison to the county and State, and non-Hispanic whites are underrepresented.

The ratio of males to females in the Greens Bayou area is similar to that of the state and county and the population tends to be somewhat younger. The Greens Bayou area population has a greater percentage of high school graduates than the county and the state, but a smaller percentage of college graduates. The percentage of females in the labor force is slightly higher in Greens Bayou area than in the county and State, and from 2000 census data, the percentage of unemployed males and females is slightly higher in the Greens Bayou area than in the county and state. In comparison to the state and county, the Greens Bayou population is underrepresented in higher-paying white-collar occupations and over represented in the less well paying service occupations. The largest numbers of males in the Greens Bayou area population are in the production, transportation, and material moving occupations and in the construction, extraction and maintenance occupations; the largest numbers of females in the population are in sales, office and service occupations.

Based on 2000 census information for 1999 household income, the Greens Bayou 1 percent annual exceedance floodplain shows a smaller percentage of the lowest income category compared to the county and the state. The median household income is about \$36,000 for the Greens Bayou area, \$49,000 for the county, and about \$39,500 for the state. There are 14,124 housing units in the Greens Bayou watershed (without-project 1 percent annual exceedance floodplain), of which 46 percent are renter-occupied, 39 percent owner-occupied, and 15 percent vacant housing units. Housing units in the Greens Bayou area show higher rates for both vacant and renter-occupied units compared to county and state housing units.

An economic analysis of the watershed area indicated that about 2,700 structures are damageable by a 1 percent annual exceedance flood event. Based on a persons-per-housing-unit ratio of about 3.0 derived for the area, an estimated 8,200 persons are susceptible to flooding by the 1 percent annual exceedance flood. This population endures the health and safety risks of a flood event that has a probability of occurrence of 1 percent in any given year.

5.10.3 Community Cohesion

The residences in the Greens Bayou floodplain are located almost entirely within subdivisions. The subdivisions are largely separated from each other and from nearby subdivisions not in the floodplain by transportation arteries, by Greens Bayou and other channels, and by areas of open land. Lack of compactness in the distribution of subdivisions has so far prohibited the emergence of named neighborhoods, as in older sections of the city. The subdivisions are loosely related by public facilities such as schools and post offices. The situation is changing rapidly with new subdivision construction in the project area vicinity and upstream. Many of the subdivisions were created prior to 1982, and others are relatively new. There are few community cohesion indicators such as churches, schools, restaurants, and parts within or near the subdivisions within the floodplain.

5.10.4 Tax Base

Property taxes account for the largest portion of the City of Houston's general fund. The city, county, and school district are the three important taxing authorities affecting a property owners taxes for property within the city limits. Differences among the school district tax rates, as well as other kinds of taxing entities such as community colleges and hospitals, account for variations in the tax rates among locations within the city. County and school district taxes are applicable within Harris County. The proposed construction area floodplain is not within the city limits of Houston, and the taxing authorities are limited to the county and to school districts.

5.10.5 Life, Health and Safety

The Greens Bayou area has been subjected to intermittent flooding over the past several decades, including the devastating event of Tropical Storm Allison in 2001. In recent years, the Greens Bayou area has reported no mortalities as a direct result of flooding. These floods have produced accidents, generated unsanitary conditions, interfered with needed medical services, disrupted normal activities, and generated fears of similar occurrences in the future. The abandoned residences resulting from flooding that have not been removed may be structurally unsound providing a hazard to persons entering them and potential for injury.

5.10.6 Transportation

The major transportation highways that traverse the Greens Bayou drainage area include U.S. Highway 59 North, the Hardy Tollroad, IH 10, and the North Sam Houston Parkway. Main transportation thoroughfares in the immediate project area include the North Sam Houston Parkway, Tomball Parkway (State Highway 259), west of the project, and Veterans Memorial Drive, immediately east of the project. The completion of the North Sam Houston Parkway has influenced commercial and residential development along its frontage roads and has opened the area to increasing development. A railroad (Burlington-Northern) is located in the upper watershed along the Tomball Parkway.

5.11 ENVIRONMENTAL JUSTICE

Executive Order (EO) 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires Federal agencies to identify and address any adverse and disproportionate impacts of their programs, policies, and activities on the health or environment of minority or low-income populations groups in the project area vicinity (Federal Register, Vol. 59, Number 32, February 16, 1994). A minority population is defined as a group of people and/or community experiencing conditions of exposure or impact that consists of persons classified by the U.S. Bureau of the Census as Black or African-American; Asian or Pacific Islander; Hispanic; American Indian, Eskimo, or Aleut; or other non-white persons. A low-income population is defined as a group of people and/or a community that as a whole lives below the national poverty level. The average poverty level threshold for a family of four people living in the United States in 2001 was a total annual income of \$17,650. Disproportionate environmental impacts from the exposure to an environmental hazard occur when the risk to a minority population or low-income population exceeds the risk to the general population. In

accordance with the EO, an analysis was performed to determine whether the proposed project will have a disproportionate adverse impact on minority or low-income population groups in the project area.

The data to determine the potential for disproportionate impacts to low income and/or minority populations within the project area are based on the 2000 U.S. Bureau of the Census state, county, census tract, and block level data for ethnicity and income. Ethnicity and race were examined for the census tracts in the proposed project construction area vicinity (Cutten Road to Veterans Memorial Road). For ethnicity, the total population of the area inhabitants is 81.8 percent minority and 17.2 percent white alone. Although highly “minority,” the racial and ethnic makeup of the area is considered quite diverse. Minority percentages are 35 percent black, 15 percent Asian, and 30 percent Hispanic. In terms of household income, about 9 percent of the households in the proposed construction area met the criteria of “economically stressed,” or households with incomes of less than \$15,000 per year. The median household income for this area is \$49,200 (1999 dollars), which is greater than either the state or county. Also, housing units in this reach were 85 percent owner occupied and 15 percent rented. The rates of home ownership are much higher for this area than for the state or county. Overall, the population in the proposed construction area appears to be in a stable and slightly advantaged economic situation, despite of a high minority ranking for the area. From an economic standpoint, the population in the construction area is not considered vulnerable to negative project effects.

5.12 LAND USE

Land use within the existing 1 percent annual exceedance floodplain is shown in the Table 24. The major categories of land use in the watershed listed in descending order are woody land, grassland, low intensity development and high intensity development.

Table 24
Land Use - Existing 1 Percent Annual Exceedance Floodplain of Greens Bayou.
Rounded to nearest hundredth of a percent.

Land Use	Percentage of Occurrence
Low Intensity Development	17.17%
High Intensity Development	16.93%
Cultivated Land	< .01%
Grassland	21.27%
Woody Land	33.95%
Open Water	2.38%
Woody Wetland	5.21%
Non-woody Wetland	2.18%
Bare/Transitional Land	0.87%

Based on information from Houston-Galveston Area Council 2002.

5.13 GEOLOGY AND SOILS

The geology of the area and general soils over which Greens Bayou flows are of Quaternary Age and are of the Houston Group. The Houston Group is divided into two formations, the Lizzie, at the base, and the Beaumont, at the top. These formations both outcrop in Harris County. Greens Bayou flows over the Beaumont Clay formation from its headwaters to its convergence with Buffalo Bayou and the Houston Ship Channel. Both the Brazos River and the Trinity River deposited these Houston Group formations during the Tertiary Age. During the Late Tertiary and early Quaternary Ages, the river systems brought in huge quantities of clay, silt, sand, and gravel from upstream sources. These sediments were spread over the Houston area and adjacent territory as the rivers shifted laterally over the nearly featureless coastal prairie. The Houston area soils generally consist of clay, having a low permeability, high water holding capacity and poor drainage. The clay has a very high shrink-swell potential, however the cycles of shrinking and swelling are minor with little excessive drying or desiccation cracking. The soils within the proposed detention basin and surrounding areas of Greens Bayou exhibit moderate to low plasticity with stiff consistency. The subsurface soils within the project area contain deposits, or layers, of clayey sands and silts, with moderate permeability.

6.0 ENVIRONMENTAL IMPACTS OF PROPOSED ACTION

6.1 IMPACTS ON BIOLOGICAL RESOURCES

6.1.1 Vegetation

Since the FEIS and project authorization, there has been a reduction in scope of the project. The proposed plan of channel modifications and detention is in the upper reaches of Greens Bayou. The proposed channel modifications on Greens Bayou in the Veteran's Memorial Drive to Cutten Road reach will result in removal of invasive grasses and shrubs within the existing ROW. The proposed channel activities would also remove some scattered areas of trees and shrubs existing along the edge of the ROW. The channel alignment has been designed to minimize the loss of trees as much as possible. Wetlands will not be impacted by the proposed channel modifications. Following construction of the channel modifications, the project design includes environmental features, as authorized in the original project, including planting of native trees on the channel slopes and berms and establishment of turf grasses on channel side slopes, flood bench berm, and ROW above top of-channel bank. The planting of native trees and the establishment of turf grasses along the channel alignment will improve the aesthetics of the channel and provide some wildlife value to birds and small mammals.

The proposed detention basin cells have been disturbed by agricultural practices, clearing, and urban encroachment, resulting in revegetation of the area by invasive vegetation of low quality wildlife habitat. The proposed detention cells contain second-growth trees, shrubs, and understory vegetation that has developed following past disturbances within the area. Native wildlife values of the proposed detention basin are low due to the disturbed, urban nature of the site. Much of the vegetation would be removed during the construction activities to create the detention basin. Prominent existing groups of trees and understory in the basin footprint will be avoided by construction and preserved providing islands of established vegetation for use by birds and small animals.

Implementation of the proposed plan will impact 14.72 acres of wetlands within detention basin footprint. For the project induced losses to wetlands that cannot be avoided, mitigation measures have been developed to replace losses of the wetland areas. As authorized by WRDA 90, environmental features are included in the detention basin design and include plantings of native trees and shrubs, establishment of turf and native grasses where possible, and development of several acres of wetland plantings in the cells. The design will include a variety of native tree and shrub plantings in the cells totaling about 2,650 trees and 1,060 shrubs on the perimeter, side slopes, and bottom of the detention basin. The proposed design would also include planting of several areas of freshwater wetland plants within the basin cell bottoms for use by aquatic birds and local wildlife. The design of the basin would include seeding of impacted areas with turf grasses to establish ground cover, reduce erosion, and improve the aesthetic appearance of the project. The environmental features in the detention basin will improve the aesthetics of the project, create mosaics of habitat within the basin cells, and provide a diversity of habitat in the area.

With the implementation of the proposed plan changes in surface water profiles in the area from the confluence with Garner's Bayou to the mouth of Greens Bayou would occur. Table 25 displays the average changes and maximum changes at any given water surface profile station that is expected from the hydraulic modeling for 2-, 5-, and 10-year flood events. These changes are considered minor since they are 3 inches or less in all instances. The minor changes in water surface elevations are not expected to impact the sensitive vegetation areas downstream of the Garner's Bayou confluence.

Table 25
Computed Decreases in Water Surface Elevation
Above Confluence with Garner's Bayou to Mouth

Event	Average Decrease	Maximum Decrease
2-year flood (.5 probability event)	1.02 inches	2.16 inches
5-year flood (.2 probability event)	.96 inches	2.76 inches
10 year flood (.1 probability event)	.55 inches	3.0 inches

6.1.2 Wildlife Resources

The loss of low quality habitat from excavation and discharge of materials will result in the migration of urban wildlife from the channel, basin, and placement areas to surrounding undeveloped areas. The wildlife is of a type that is adapted to human activities, vacating habitat at the time of disturbance, populating similar adjacent habitat, and returning after habitat has reestablished. After excavation, the channel, basins, and PAs will be reseeded with a mix of grasses. Invasive plant species of the types lost to construction will revegetate portions of these areas. As a result, this may cause a change in types of wildlife species; with many of the species of small mammals, birds, reptiles, and amphibians returning to their former territories while some terrestrial mammals may not. The proposed wetlands created in the detention basin may attract species of wildlife different from and in greater numbers than those now found there. The same may apply for the plantings of native trees and shrubs along the channel and in the basins.

6.1.3 Aquatic Resources

Greens Bayou currently provides poor aquatic habitat. Proposed construction in the upper portion of the bayou, which has been previously channelized, will result in disturbance of the channel bottom and loss of some aquatic organisms. Most of the fish, vertebrates, and invertebrates are mobile and will migrate from that portion of the channel under construction. After excavation, a stabilized channel bottom and decreased turbidity will encourage repopulation of the channel over time by the same types of aquatic organisms found there now. This is expected because the types of fish, vertebrates, and invertebrates currently inhabiting the bayou colonized it after its previous channelization. It is anticipated there will be no permanent change in the water quality of the bayou overall to affect species population or diversity. Impacts from the proposed plan will not be significant to fishery resources within the project area.

6.1.4 Placement of Excavated Materials

The placement of excavated materials into PAs for the authorized project has been discussed in the Feasibility Report and FEIS. Construction of the proposed channel modifications and the detention basin will involve excavation of about 3 million cubic yards of material. Materials will be excavated by land-based equipment and hauled away from the construction areas for placement in proposed upland sites or disposed of at the contractor's option. Some of the excavated materials may be sold as fill material in the Houston area. Current estimates indicate that about 198 acres of lands could be required for placement of the excavated materials. The potential PA sites are generally located on open urban land tracts and disturbed grasslands and pasture that have low wildlife habitat quality. Placement of material in the upland PAs will eventually result in the loss of most of the existing vegetation. No wetlands or other sensitive areas of vegetation will be impacted by placement of excavated materials. Urban wildlife will likely avoid the disturbed areas during placement operations.

PA easements will be required for use during construction. Excavated materials will be deposited in PAs to heights from 5 to 10 feet above the ground surface in order to minimize land requirements. Containment levees are not required for the PAs. The PAs will be graded and sloped to drain and planted with grasses after completion of placement activities. As revegetation occurs, the areas would be used by wildlife.

6.2 IMPACTS ON THREATENED AND ENDANGERED SPECIES

No impacts on any federally-listed species are anticipated from the proposed project. No project impacts on the bald eagle will occur. The project area lacks tall, large trees near large bodies of water attractive to nesting bald eagles. Eagles may pass over the area during migration, but their mobility allows them to easily avoid construction activities. No prime supporting habitat will be lost to project activities.

Texas prairie dawn was identified by USFWS as potentially occurring in the project area. The channel alignment area has been disturbed by past flood control work and proposed channel modifications would have no impact on the prairie dawn. The detention basin site was surveyed for prairie dawn by USACE staff with negative results. No suitable habitat for Texas prairie dawn was identified in the detention basin areas or the placement areas. The potential placement areas have been cleared or extensively disturbed by activities related to agriculture and land development and do not provide potential habitat for the plant. The proposed project activities will not have any impacts on Texas prairie dawn.

6.3 IMPACTS ON WATER QUALITY

Water quality conditions in Greens Bayou and effects of the authorized project on water quality in the project area were discussed in the FEIS. Although excess excavated material will be placed into upland placement sites away from the bayou, the channel modifications and construction of the detention basin will involve some placement of materials into waters of the United States. A Section 404(b)(1) evaluation of this placement of materials required by the Clean Water Act was prepared and submitted with the FEIS for the authorized project. The

evaluation concluded that the project authorized in the FEIS was in compliance with Section 404 of the Clean Water Act and that no adverse impacts to water quality will occur. The proposed construction of channel modifications and detention features will not cause any negative meaningful change in the previous assessment of water quality impacts reported in the FEIS. The mitigation that has been developed for wetland impacts is expected to provide some incidental water quality improvements for Greens Bayou during low flow periods. The water quality effects will include increases in turbidity levels localized and short-term in duration. The turbidity will dissipate soon after completion of excavation activities. Placement of excavated materials in upland sites away from the bayou will not result in adverse impacts to bayou water quality. A Section 404(b)(1) evaluation for the proposed project activity is included in Appendix B that shows that the proposed project is in compliance with Section 404 of the Clean Water Act and that no adverse impacts to water quality will occur.

Section 402(p) of the Clean Water Act, National Pollutant Discharge Elimination System (NPDES) Storm Water Discharge from Construction Activities will be applied to the Greens Bayou project. Under this permitting regulation, erosion and sediment control methods and best management techniques will be incorporated into the project design and construction sequences to minimize water quality impacts to the bayou. Erosion and sediment control methods may include use of silt fences, hay bales, temporary vegetation, straw cover or other methods. Seeding and fertilization of channel side slopes and detention berms, side slopes and basin bottoms will be performed following excavation to establish ground cover and prevent erosion of excavated areas. Storm water controls will also be utilized at PAs for excavated materials to minimize impacts to other nearby water bodies.

6.4 IMPACTS ON HISTORIC PROPERTIES

Historical research and a historic properties survey of all areas to be affected by channel modifications and detention basin excavation were conducted in 1998 (Gadus and Moss, 1998). The requirements and results of this survey were coordinated with the Texas State Historic Preservation Officer (SHPO). Copies of this correspondence are provided in Appendix C. The SHPO concurred with the report's recommendation that of the seven sites recorded in the general area, only 41HR709 (the Hargrave-Hilton cemetery) was potentially eligible for the National Register. This site will not be affected by channel modifications or detention activities. Although it is located in a proposed detention basin owned by HCFCD, it is not a feature of the USACE project and no treatment for this site is proposed. No sites were found in the detention basin proposed for this project and no potentially eligible sites were located in channel modification impact areas.

A reconnaissance survey of the proposed PAs was also conducted in 1998 (Stokes, 1999). All of the proposed PAs are located well away from the Greens Bayou floodplain in areas with very little potential for prehistoric sites. Historical research has shown that historic settlers bypassed this area until the early 20th century, resulting in a low potential for historic-era resources as well. The reconnaissance survey and historic map research found no indication of any cultural resource in the proposed PAs.

Based upon the research and surveys discussed above, no historic properties are likely to be affected in areas proposed for channel modification, detention basin excavation, and placement activities.

6.5 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW) IMPACTS

An HTRW investigation was performed in 1993 and then updated in 1999 and 2004 to evaluate the relative risks of encountering hazardous wastes or substances in the project area. Research into various agency records, historic land uses and site surveys indicates the project area has not been impacted by regulated materials or wastes that could have been spilled, released or dumped. The majority of lands in the project area were undeveloped prior to the 1940's, with the exception of some minor petroleum exploration. In the 1950's and 60's, the area experienced construction of family residences and commercial development and commercial development. During the 1970's, the project area had undergone considerable development, primarily residential subdivisions and further commercial development. The project area continued further subdivision and commercial development during the 1980's and 90's. The analysis indicated no areas within the immediate project area or nearby which could be associated with potential HTRW sites.

Although regulatory agency files indicate limited historic oil and gas drilling activities and several pipeline crossings within the project area, contamination from these sources is considered unlikely. The occurrence of pipelines crossing the project area should be noted in order to take proper measures for channel excavation activities, although there is little potential of encountering contamination from pipelines that have affected the sediments of the project area.

Investigations for the HTRW survey indicate there are no HTRW sites in the project area. As such, the probability of increased project cost and/or lost time from discovery and remediation of any contaminated materials within the project area is considered low. Based upon information compiled by this survey, additional investigations related to HTRW issues are not warranted at this time.

6.6 IMPACTS ON AIR QUALITY AND NOISE

6.6.1 Impacts on Air Quality

The proposed project is expected to result in some temporary impacts to air quality during construction. Proposed construction will result in minor short-term exhaust emissions and increase in dust levels from machinery and equipment in the immediate vicinity of the project site. The potential air emission sources during construction could include front-end loaders, bulldozers, trucks, backhoes, and other construction equipment. Excavation at the site will be most intensive during the construction of the detention basin. Trucks will mainly be traveling on 4 lane roads and the access roads of the Sam Houston Tollway. This amount of traffic is not expected to cause any significant effect on the air quality of the area. The Sam Houston Tollway is a heavily traveled major highway corridor capable of handling the truck traffic. Construction on the channel modifications is expected to require far fewer trucks to transport material.

A preliminary analysis of air contaminant emissions for the Greens Bayou Project was done to determine if the construction of the proposed plan would generate nitrogen oxide (NO_x) and volatile organic compound (VOC) emissions (ozone precursors) above de minimus levels specified in the General Conformity rules, as established by the Clean Air Act, for the Houston Galveston Nonattainment Area (PBS&J, 2005). Currently, the HGA is classified as a severe nonattainment area for ozone under the 1-hour National Ambient Air Quality Standard for ozone. However, the U.S. Environmental Protection Agency has recently promulgated an 8-hour ozone standard to replace the 1-hour standard. Based on the 8-hr ozone standard, the HGA will be reclassified to a moderate nonattainment area effective June 15, 2005. Accordingly, for this moderate classification, a General Conformity Analysis would not be required if NO_x or VOC emissions would be below 100 tons per year (tpy) for either NO_x or VOC. The project is scheduled to begin production in November 2005. Therefore, de minimus level used are 100 tpy each for NO_x and VOC. The results of the preliminary analysis are shown in Table 26.

Table 26
Comparison of Estimated Emissions (tons/year) to General Conformity Thresholds

	VOC					NO _x				
Year	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009
Tons/year	0.86	3.97	0.34	0.15	0.05	12.38	66.37	5.16	1.68	0.77
General Conformity Threshold (tons/year)	100	100	100	100	100	100	100	100	100	100
Exceeds Threshold	No	No	No	No	No	No	No	No	No	No

These impacts on ambient air from construction emissions will be minor and temporary in nature. Contractors will be required to follow Federal, state, and local regulations and ordinances regarding air emissions from construction activities and control of fugitive dust. Contractors will be required to use appropriate techniques to minimize exhaust and dust emissions and perform equipment maintenance.

6.6.2 Noise Impacts

Noise levels will be slightly increased during construction from operation of equipment, work crew activities, and passing of trucks and other vehicles. Construction noise lasts only for the duration of the construction contract and is usually limited to daylight hours to minimize the potential impacts of construction-related sound to surrounding areas. Extended disruption of normal activities to residents or businesses is not expected to occur because of the relatively short-term exposure periods on any one receiver during construction. The construction contractor will be required to follow noise reduction measures such as work-hour controls and proper equipment maintenance. No significant impacts related to construction or truck traffic sound will occur as a result of the project.

6.7 IMPACTS ON RECREATION

A consideration of the recreation analysis was to avoid conflict with the Land and Water Conservation Fund and the Local Parks and Recreation and Open Space Fund. Recreation areas and facilities developed or purchased with these funds have a general provision that these areas will be for public recreation use only. The proposed plan will not impact public recreation areas or facilities developed or purchased under these programs. There will not be a loss of capital improvements to private parks or of acreage specifically dedicated to recreation.

Any proposed recreational development by local interests at the project will benefit the residents of the watershed by providing recreation facilities in a heavily developed area currently underdeveloped with such facilities. Recreation development would be a welcome addition to the area.

6.8 IMPACTS ON PRIME AND UNIQUE FARMLANDS

The recommended plan will have no adverse effect on any lands considered as prime or unique farmlands.

6.9 SOCIOECONOMIC IMPACTS

Socioeconomic effects associated with the channel and detention basin implementation can be differentiated as impacts generated during the construction phase of the project and as impacts due to the operation of the project. The construction effects are generally of limited duration, usually impacting only the population in the immediate vicinity of the construction site, while the operation effects last the length of the project's life. Short-term construction effects generally are related to expenditures for work performed usually by contractors and to the operation of construction equipment in the immediate area of the stream and detention basin. Long-term operation effects generally are related to the level of flood protection afforded to the watershed.

6.9.1 Demographics

Construction of the project will provide benefits of flood frequency reduction for the population in the 1 percent annual exceedance floodplain in the watershed. The effects of flood frequency reductions and the elimination of areas from the 1 percent annual exceedance floodplain will be beneficial to residents, the owners of commercial and industrial facilities, and the general public through the protection of public buildings. The residential beneficiaries will include a wide range of racial and minority types and income levels. Implementation of the project plan will remove approximately 1,600 people from the 1 percent annual exceedance floodplain of Greens Bayou. Not only will savings accrue to local residents through a reduction in expenses associated with flooding, but also the reduced threat of flooding could potentially restore the value of property depressed by the stigma of repeated flood events. The proposed project will not require purchase or removal of residential or other structures for construction of the project.

6.9.2 Community Cohesion

Construction of the project will result in reductions in flood frequencies and have a positive effect on community cohesion throughout the floodplain. The flood damage reduction aspects of the project will benefit residents throughout the floodplain, and these benefits will be increased if recreational and environmental quality features are implemented.

6.9.3 Tax Base and Income

Construction of the project will have a positive effect on tax revenues from properties in the Greens Bayou floodplain by removing properties from the 1 percent annual exceedance floodplain, thereby increasing their value and the potential for development. Increased flood protection will also reduce the potential for the lowering of property values through damages to structures. The proposed improvements will also result in savings in costs related to administering the National flood Insurance Program (NFIP). During construction, the proposed project will temporarily increase employment and incomes in the local economy as construction-related expenditures are increased. The proposed project will not influence long-term employment or income levels.

6.9.4 Life, Health and Safety

Construction of the project will have a positive effect on life, health and safety. The project would reduce the severity and extent of all floods but would not eliminate the threat of floods of the magnitude of Tropical Storm Allison in 2001. The risk of injury or death of floodplain residents and emergency response personnel will be reduced. Also, the flood associated unsanitary conditions, disease vectors, and the number of flood-damaged structures abandoned or vacant for long periods after a flood will be reduced. Reducing the presence of such structures will reduce the fire risk and risk of injury to children in the affected area. Based on data from a structure inventory in the floodplain and assuming construction of the project, it is estimated the proposed project will keep about 720 structures including apartment buildings, commercial structures, public structures, and residences from flooding within the 1 percent annual exceedance impact area (GEC, 2003).

6.9.5 Community Services

Project construction will reduce the level of need for police protection, emergency medical services, and fire departments in the Greens Bayou area during flood events and will provide positive benefits over the long-term. The proposed project will aid emergency vehicles access to destinations within the project area through the reduction of flooded streets and subdivisions.

6.9.6 Transportation

With implementation of the project, there will be a reduction in road inundation and closure by floodwaters in the floodplain. It is expected that flood debris on roads will be reduced. Road foundations will be less weakened and maintenance costs will be reduced as the extent and time of road inundation is lessened. This will have a positive impact on the road and street system in

the project area. The project will involve truck hauling of excavated materials from the construction site to remove the materials from the channel and detention basin. Numerous transport routes with high carrying capacities are available in the project vicinity. The activity will have minor short-term impacts on existing traffic patterns during construction of the project.

6.9.7 Aesthetics

The project will result in reduction in flooding that will reduce the potential for unsightly damaged or abandoned structures in the floodplain and the accumulation of flood-generated debris and trash. Aesthetics will be improved at the project in the long-term with the implementation of environmental quality features and potential recreation features. The detention basin will ensure the long-term availability of open, green space in the area. Landscaping and other environmental features will provide improved views at the project features.

6.9.8 Placement Areas

PAs have been identified as potential sites to receive excavated material from the project features, if necessary. However, intense development pressure makes the ultimate use of these sites questionable. The sites that will be used will undergo a grade raising up to 10 feet above ground depending on location and capacity requirements. PAs proposed to accept materials from excavation of the channel and detention basin are located primarily in disturbed open areas and fields. Materials excavated from the detention basin will be hauled to the PAs using existing access routes in the area. Areas surrounding the PAs will experience an increase in truck traffic during the construction period as well as noise and dust from operation of haul trucks, heavy equipment and machinery. These effects will last only as long as a site is used to accept excavated materials. Disruption of normal activities associated with the surrounding residents and businesses is not anticipated.

6.10 ENVIRONMENTAL JUSTICE

The potential for environmental justice concerns was considered during reevaluation studies for the Greens Bayou project in accordance with EO 12898. An environmental justice analysis was conducted in the fall of 2003 to determine the potential for disproportionately high adverse impacts to low-income or minority populations within the proposed project area. The proposed construction area vicinity is comprised of about 81.8 percent minority populations with a relatively low percentage of households meeting the criteria of “economically stressed.” The population in the proposed construction area appears to be in a stable and slightly advantaged economic situation, despite a high minority percentage for the area. From an economic standpoint, the population in the construction area is not considered vulnerable to negative project effects. There will be no residential or commercial structures displacements required for the project.

The proposed plan will have a positive effect on the social and economic conditions in the project area. Implementing the plan will reduce flood damages to residences and businesses during flood events, resulting in a positive effect on the value and potential of properties.

Positive effects will also include a reduction in potential flood related deaths and fewer disruptive evacuation requests to the population. If recreation facilities are eventually developed in the detention area, the benefit will be available to the entire community. Adverse effects associated with the construction, such as increased noise levels and traffic disruptions will be temporary and cease upon completion of the project. The long-term beneficial effects of the project, including reduced flooding and flood damage, will outweigh the temporary adverse effects and provide a positive impact to minority and low-income populations. The proposed project will not result in disproportionately high and adverse human health or environmental effects on minority and low-income populations (GEC, 2003).

Executive Order 13045, "Protection of Children from Environmental Health Risks and Safety risks," mandates that Federal agencies identify and assess environmental health and safety risks that may disproportionately affect children as a result of the implementation of Federal programs and activities. The proposed project will be beneficial to the community population and not disproportionately impact the environmental health or safety of children in accordance with EO 13045.

6.11 IMPACTS ON LAND USE

The recommended plan will not have a significant adverse impact on land use. The areas impacted will be replanted with vegetation including trees and shrubs. The land use of the project lands under the recommended plan will be similar to the existing condition.

6.12 IMPACTS ON GEOLOGY AND SOILS

The recommended plan will not negatively impact the geology and soils of the project area. Topsoil will be removed and held during project construction and then reapplied to the areas that were disturbed during construction prior to revegetation.

6.13 MITIGATION

The recommended plan includes mitigation measures to offset the loss of 14.72 acres of wetlands that would be lost as a result of construction of the plan. The 14.72 acres of wetlands identified within the detention basin footprint that will be impacted will be mitigated through the creation of 16.3 acres of wetlands. Of the 16.3 acres of wetland creation, 4.2 acres will be constructed along the pilot channel of Greens Bayou for the length of the project (3.7 miles) while the remaining 12.1 acres will be constructed within the detention basin. The proposed mitigation is both cost effective and incrementally justified. Appendix D contains detailed information relating to the Habitat Evaluation Procedure (HEP) and Cost Effectiveness/Incremental Cost Analysis (CE/ICA) that were completed to aid in the selection of the mitigation plan.

Proposed mitigation includes creation of wetlands both in the detention basin and along the channel of Greens Bayou. The 12.1 acres of wetlands within the detention basin will be constructed at elevations below the proposed basin bottom ranging between 6 inches and 2 feet below grade. The 4.2 acres of wetlands within the bayou will consist of 5-foot wide wetland areas extending along both sides of the pilot channel for the entire length of the channelization

(3.7 miles). These wetlands are expected to improve the water quality of Greens Bayou during low flow periods. The constructed wetlands will be planted with the following species: sweetflag, meadow foxtail, sedge (*Carex* sp.), white-top sedge, spikerush, lovegrass, half-bred-leaf, rosemallow, spider lily, soft rush, cardinal flower, maiden-cane, switch grass, beakrush, arrowhead, American bulrush, *Spartina alterniflora*, *Spartina patens*, and bald cypress.

7.0 CUMULATIVE IMPACTS AND OTHER RELATED ANALYSES

Cumulative impacts to the environment are defined by the Council on Environmental Quality's (CEQ) regulations as the incremental effect of the proposed action when added to other past, present, and reasonable foreseeable future actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time. Ecological effects refer to effects on natural resources and on the components, structures, and functioning of affected ecosystems, whether direct, indirect, or cumulative.

Adverse impacts on natural resources in the Houston area have resulted from general trends in population growth and economic development. Such effects are expected to continue to occur as a result of development related to normal growth in the region. These impacts and impacts resulting from the proposed action combine and interact to result in cumulative effects upon the area of influence, which includes Houston and Harris County. Assessing potential cumulative effects related to the proposed action involves a summary and assessment of other projects occurring within the general Houston area. A number of actions that have been or are likely to be undertaken by Federal and non-Federal agencies and private interests may have some degree of direct or indirect impact on the environment. These actions are discussed below. Beneficial effects of development in the general project area include new economic opportunities, housing alternatives, employment opportunities, and recreational resources. Potentially adverse cumulative effects associated with the continued development of the area include conversion of land uses, loss of habitat, and air and water quality impacts.

The following is a brief description of past, present and future actions that have been identified that may contribute to overall cumulative effects in the area when considered along with the proposed project.

Texas Department of Transportation (TXDOT) Projects. TXDOT has several planned road and highway projects and studies that would impact the Harris County area. These include improvements along U.S. Highway 59, IH-45, IH-10, and the West Loop 610. The TXDOT is the local lead agency on these transportation projects. The Sam Houston Toll Road Beltway 8 Project is under construction and is sponsored by the Harris County Toll Road Authority. TXDOT is also constructing transportation improvements to IH-10 between its intersection with the 610 Loop West and to Highway 6 to the west. Social and economic effects and environmental impacts will be addressed for each of these projects by TXDOT.

Grand Parkway. The Grand Parkway (State Highway 99) is a proposed 170-mile highway that would encircle the greater Houston area and eventually traverse seven surrounding counties. The purpose of the project is to complete the area's regional mobility plan. The Grand Parkway has been divided into nine segments by the TXDOT. Segment I-2, from State Highway (SH) 146 to IH-10 near Baytown, Texas, is currently being developed and would be the second part of SH 99 constructed. The project studies for this segment were initiated in 1991 and an EIS was prepared. The ROD for the EIS was signed in August of 1998.

Transportation Improvement Plan (TIP). The TIP is a staged 3- to 5-year prioritized program of transportation projects in the Houston metropolitan planning area. The plan is

designed to be consistent with the Metropolitan Transportation Plan (MTP). This program is required for a locality to receive Federal transit and highway grants. The TIP contains an annual or biennial plan that lists all transportation project activities that receive Federal funding for a given one or two-year period.

George W. Bush International Airport. Improvements to the George W. Bush International Airport are currently underway. Houston Airport Systems, in conjunction with the Federal Aviation Administration and the City of Houston, is currently constructing additional commercial runways and terminals. The expansion project is a direct response to the recent socioeconomic growth and development in the Houston metropolitan area.

American Acryl Facility. The facility build within the Pasadena Industrial District at Bayport (Port Road and Old Highway 146) began operating in 2001 with the capacity to generate 265-million-pounds-per-year of acrylic acid. Permits for air emissions for the facility were approved by TCEQ on May 3, 2000.

Deepening and Widening of the Houston Ship Channel. This project involves deepening and widening the Houston Ship Channel and deepening the Galveston Channel. A cumulative effect assessment was performed to assess the combined effects of several authorized and planned Federal navigation channel projects in the Galveston Bay area. The results of the assessment indicated that the proposed construction of marshes, bird islands, shoreline stabilization, and upland confined disposal result in positive cumulative effects to the Galveston Bay ecosystem.

Bayport Container and Cruise Terminal. The Bayport Container and Cruise Terminal proposed by the Port of Houston Authority was permitted by the USACE Galveston District in January 2004. The facility will include 7 container and 3 cruise berths and will be built on approximately 1100 acres located adjacent to the Bayport Channel.

Federal Flood Damage Reduction Projects. Several Federal flood damage reduction projects, such as the proposed project, are under consideration by HCFCD and the USACE, and are being developed within the watersheds of Brays Bayou, Hunting Bayou, White Oak Bayou, Buffalo Bayou, and Halls Bayou. These projects are considering a variety of structural and nonstructural measures in an attempt to reduce flood damages to industrial, commercial and residential development. As a result of implementation of flood damage reduction plans that are developed for the projects, it can be expected that existing flood-prone structures would be removed from the 1 percent annual exceedance floodplain and annual flood damages would be reduced within the county. Short-term impacts to natural resources would likely occur during construction of the projects, but none of the projects are expected to result in long-term impacts to the area. The projects may result in some improvements to water quality along the bayous if restoration or mitigation features are implemented. There could be a net gain in habitat with the implementation of environmental features, restoration or mitigation plans, and revegetation of impacted areas and potential placement areas. Also, recreation plans may be developed that would add new small recreation areas to the watersheds. The overall cumulative impacts of the proposed flood control projects would likely be beneficial for the human and natural resources of the area.

The potential impacts of general trends in land use and population growth, economic development, habitat impacts, air and water impacts, and social impacts associated with the above projects and the proposed project, combine to result in cumulative effects in the general Houston area. Beneficial effects of development in the general area include new economic opportunities, housing alternatives, employment opportunities, and recreational resources. As development occurs, the need for additional infrastructure and services increases. Potentially adverse cumulative effects associated with the continued development of the area include conversion of land uses, loss of habitat, and air and water quality impacts. Consideration of cumulative effects follows.

Land Use. The growth of the Houston area since the 1970's has been influenced by an increase in bedroom communities in surrounding counties. The distribution of metropolitan growth has changed over time. The Houston metropolitan statistical area has more than doubled in population (114 percent) in comparison with the state's 86 percent increase in population over the past 30 years (1970-2000). Residential development in the area has been occurring at a relatively rapid pace and involves the mass construction of a large number of homes as well as the infrastructure necessary to support this development. Additional housing, infrastructure, and commercial and public land uses required to serve the population growth projections for the area would result in continued development and land use changes. Residential development is expected to continue in the City of Houston and surrounding communities in the area in the foreseeable future. Retail and institutional development, office and industrial park construction, and commercial developments such as retail shops, restaurants, and convenience stores typically occur with residential expansion.

Economic Considerations. Residential, commercial, office, industrial, and other types of development in the Houston area are accompanied by increased economic opportunity and area employment. In Harris County, major employment sectors are retail trade, manufacturing, administrative and support, waste management and remediation services. The unemployment rate for the region has historically been lower than that of the State. The proposed project is expected to have a positive effect on the social and economic conditions in the watershed. Implementation of the project would reduce flood damages resulting in a positive effect on the value of properties. The project construction related activities would result in a slight increase in jobs and income. However, these gains will be insignificant within the overall context of economic activity in the Houston area.

Terrestrial Habitats. Developmental impacts associated with urban growth in the area result in conversion of upland, riparian, and wetland habitats and agricultural lands into residential, commercial, or industrial land uses, as well as additional infrastructure and service-related activities. Habitat fragmentation from infrastructure construction or changes in land use have disrupted and dispersed fish and wildlife populations. Beneficial uses of detention basins can aid in efforts to preserve, restore, and create valuable habitat by creating open areas as an opportunity to plant native vegetation and develop wetlands. The expected continued urbanization of the Houston area would result in pressure on wetlands and other valuable wildlife habitats. To a large extent, impacts to valuable habitats and protected species within the area would be avoided, minimized or mitigated by compliance with existing Federal statutes (Clean

Water and Endangered Species Acts) that apply to private and governmental interests. These regulations should minimize adverse effects on protected ecological resources as a cumulative consequence of continuing development activities.

Water Quality. Various existing and planned developments in the area have a cumulative water quality impact on the receiving water bodies from wastewater discharges and urban runoff. Surface water quality impacts of new development include point source and non-point source discharges. Point source discharges are regulated by the Texas Point Discharge Elimination System (TPDES) that is administered by the TCEQ to protect the quality of the receiving water bodies. Runoff from developed sites is a major contributor of non-point source discharges. These discharges are regulated under the TPDES stormwater program for construction and industrial multi-sector activities. In accordance with stormwater regulations, the water quality impacts of runoff are mitigated by Best Management Plans (BMP). Use of BMPs for controlling runoff and thereby limiting potential contamination of the aquatic habitat, and spill prevention and control measures for minimizing impacts of accidental spills result in minimal adverse impacts to water quality and aquatic resources.

Greens Bayou and other bayous and drainages in the Houston area have been subject to channel modifications for the past several decades. These actions have resulted in impacts to water quality, but the impacts tend to be temporary and localized in nature. Similar activities for other projects in the region can be expected to have similar temporary effects on water quality and aquatic habitat. The proposed project and associated mitigation is expected to provide incidental water quality improvement during low flow periods and is not expected to make a major contribution to cumulative water quality impacts.

Air Quality. The study area for assessing cumulative effects is generally located within the Houston-Galveston Air Quality Control Region, also referred to as the HGA. Ozone is the only criteria pollutant for which the HGA fails to meet the NAAQS. Currently, the HGA is classified as a severe nonattainment area for ozone under the 1-hour National Ambient Air Quality Standard for ozone. However, the U.S. Environmental Protection Agency has recently promulgated an 8-hour ozone standard to replace the 1-hour standard. Based on the 8-hr ozone standard, the HGA will be reclassified to a moderate nonattainment area effective June 15, 2005. Even with increased growth in the area, historical ambient air monitoring data for the HGA indicates a long-term downward trend in ozone. This is generally the result of efforts made to reduce emissions from various sources of VOCs. Since being classified as non-attainment with the ozone standard, many new controls on emissions have been implemented within the HGA since 1990, which have significantly reduced emissions of VOCs and will further reduce emissions of NO_x in the area.

Air quality impacts associated with the construction of planned transportation and industrial projects would result in a temporary impact on air quality. Emissions from these activities would be intermittent and of relatively short duration, generally ending when the construction activity ends. Although somewhat localized, emissions from the construction of transportation and navigation-related projects would be spread throughout the HGA as different project segments are completed. Emissions of NO_x and VOC for miscellaneous construction activities and transportation related activities are monitored by the Texas State Implementation Plan (SIP). In

the development of the SIP, the TCEQ has established a construction emissions budget for NO_x and VOC that considers and allows for construction in the HGA due to growth. In addition, projects that are considered Federal actions must undergo an evaluation of conformity with the SIP (i.e., its emissions must be demonstrated to be included within the SIP emissions budget). As it is likely that the construction activities related to reasonably foreseeable actions and the proposed project are spatially separated by considerable distances, the potential short-term cumulative air quality impacts due to construction activities associated with the foreseeable and proposed projects would not impair or prevent the HGA from continuing progress in air quality improvement under the SIP.

Hazardous Materials. The risk of contamination of soils, surface water, and groundwater as a result of construction of the proposed project is low. There are no areas within the immediate project area or nearby which could be associated with potential hazardous waste impacts and the cumulative effects to HTRW sites should not be significant.

Conclusions. Adverse impacts on natural resources in the Houston area have resulted from general trends in population growth and economic development. These trends are expected to continue to occur as a result of continued development and growth, including specific projects described earlier in this section. Potentially adverse cumulative effects associated with the past and continued development in the future include loss of habitat, air and water quality impacts, and conversion of land uses. Beneficial effects of development in the region include new economic opportunities, housing alternatives, employment opportunities and recreational resources.

Development impacts associated with normal growth in the Houston area are expected to result in conversion of wetland, riparian, and upland habitats and agricultural lands into commercial, residential, or industrial land uses, as well as infrastructure and services as people continue to move into the area. Artificial and natural processes, including historical, human-induced subsidence and relative sea level rise as well as draining and filling wetlands for development have resulted in the conversion of wetland habitats to open water or upland habitat. Losses to wetlands and other habitats since the 1950s and the continued urbanization and industrialization of the Houston-Galveston area would cause continued pressure on these habitats, efforts to preserve, restore and create valuable habitat are underway that should ensure the ecosystem's sustainability despite continuing pressure of development in the region. Beneficial uses of detention basins would aid in this effort by creating open areas and wetlands to support plant growth and wildlife. To a large extent, impacts to wetlands and protected species within the Houston area would be avoided, minimized, or mitigated by compliance with existing Federal statutes that apply to private and government interests.

Various existing and planned developments in the area have a potential cumulative water quality impact on the receiving water bodies in the area due to wastewater discharges and urban runoff. Use of BMPs for controlling runoff and thereby limiting potential contamination of the open bay habitat, and spill prevention and control measures for minimizing impacts of accidental spills would result in minimal adverse impacts to water quality and aquatic resources.

As the HGA continues to experience growth in the regional population and economy, the resulting increases in traffic and industrial capacity would be expected to contribute to additional and varying amounts of air pollution emissions. Within the Houston-Galveston Air Quality Control Region, ozone is the only criteria pollutant for which the region fails to meet the NAAQS. Even with increased growth in the area, historical ambient air monitoring data for the HGA indicates a long-term downward trend in ozone. This is generally the result of efforts made to reduce emissions from various sources of NO_x and VOCs. The existing SIP has successfully resulted in the reduction of ozone emissions to the point that the HGA has been reclassified from a severe to a moderate nonattainment area.

Air emissions from the proposed action added to other past, present and reasonably foreseeable future actions would be addressed by TCEQ, EPA, and the SIP. The TCEQ and EPA are responsible for monitoring and tracking air quality levels and the identification of potential air quality exceedances. Adjustments would be made to the SIP, as appropriate, to achieve and then to maintain attainment of the standards.

In conclusion, the many projects occurring in the general vicinity of the proposed activities within the Greens Bayou watershed are part of the continued urbanization and industrialization of the Houston area. The potential cumulative effects of these projects accompany this trend and would affect environmental, social, and economic receptors. However, the proposed project includes mitigation for impacts to wetland areas, is expected to provide a long term incidental improvement to the water quality of Greens Bayou, and ensure that the project lands remain as greenspace. In addition, existing governmental regulations, in conjunction with the goals and coordination of community planning efforts, address the many and varied issues that influence the local and ecosystem-level conditions. The vision, goals and, ultimately, the coordination of the numerous stakeholder groups by local organizations, and the regulatory powers of State and Federal programs in addition to regulations such as the TCMP, the Clean Water Act, and the Clean Air Act, serve to safeguard these resources and prevent or minimize negative impacts that would threaten the general health and sustainability of the region.

8.0 PUBLIC INVOLVEMENT, REVIEW AND CONSULTATION

8.1 PUBLIC INVOLVEMENT PROGRAM

A number of public concerns have been identified for this study area beginning in the early 1980's. Initial concerns were expressed in the study authorization. Additional input was received through coordination with the Non-Federal Sponsor and coordination with other agencies.

Partnering meetings were held after the initiation of the GRR to identify neighborhoods and specific locations that sustained recent flood damages along the bayou. A public notice was issued to inform residents, Federal, State and local agencies, organizations, interested groups and the public in December 1996 about reevaluation studies and to receive input. Information and suggestions received from these coordination activities were considered in the study.

A project newsletter and project web site (www.greensbayouproject.com) was developed in August 2003 to provide updated information about the flood damage reduction project and request input on the project. A public meeting was held in Houston, Texas, at Klein Forest High School in September 2003 to inform the public and organizations about the proposed flood damage reduction project and to request input and comment. Information and suggestions received from these coordination activities have been considered in developing the recommended plan.

8.2 INSTITUTIONAL INVOLVEMENT

Project Delivery Team. During the reevaluation, staff from the HCFCD participated as members of the project delivery team. They participated directly in the study effort and on the Executive Committee. This involvement has led to support for the implementation of the recommended plan.

Agency Participation. During the reevaluation study, coordination with the USFWS was conducted in accordance with the Fish and Wildlife Coordination Act. The USFWS has provided the USACE with a final Coordination Act Report that includes their views on the recommended plan. All USFWS recommendations have been given full consideration. The USFWS has coordinated their report with the NMFS and the Texas Parks and Wildlife Department. The views of Federal, State, and local agencies are summarized as follows:

The USFWS prepared planning aid letters for the project in November 1998 and December 2003. The reports describe the proposed project, update fish and wildlife conditions, evaluate potential impacts of the proposed plan, and present discussion and recommendations. The fish and wildlife discussion and recommendations have been considered in developing the Recommended Plan.

The USFWS was contacted to update the list of threatened or endangered species potentially found in the project area (Appendix A). Based on available information and field investigations, the Galveston District has determined that the recommended plan will not have any adverse impacts on any federally-listed threatened or endangered species. The USFWS will be requested to concur with the determination.

Historical/archival research and archeological surveys of the proposed structural plan components were coordinated with the Texas SHPO. The SHPO concurred in the USACE finding that no historic properties are likely to be affected within the area of potential effects for the proposed Greens Bayou flood control project.

Resource agencies and individuals were contacted for information on HTRW sites and water quality in the project area and proposed construction areas. Agencies contacted included the TCEQ, Texas Railroad Commission, Texas Department of Health and Harris County Health Department, Harris County Pollution Control Department, and HCFCD. An assessment concluded that the probability of encountering HTRW sites during project construction was low.

8.3 ADDITIONAL REQUIRED COORDINATION

This GRR and environmental assessment (EA) has been prepared to satisfy the requirements of all applicable environmental laws and regulations. The document has been prepared using the USACE regulation, ER 200-2-2, (Environmental Quality: Procedures for Implementing NEPA, 33 CFR 230) and the CEQ, NEPA regulations (40 CFR Part 1500). The following is a brief discussion of environmental review and consultation requirements applicable to this project:

National Environmental Policy Act (NEPA). The document has been prepared in accordance with CEQ regulations to aid in complying with NEPA. The environmental, economic and social consequences of the recommended plan have been analyzed in accordance with the act and presented in the report.

Fish and Wildlife Coordination Act of 1958, as amended. The proposed project has been coordinated with USFWS, TPWD, and other appropriate resource agencies throughout feasibility planning and reevaluation studies. The USFWS has provided updated information on fish and wildlife resources and provided planning input on channel and detention plans during reevaluation. The USFWS prepared fish and wildlife planning aid reports for the reevaluation study (Appendix C). No significant concerns were identified by the agencies and no unresolved issues remain.

Endangered Species Act of 1973, as amended. The USFWS was contacted regarding endangered, threatened or proposed species and their critical habitats potentially found in the project area (Appendix A). Available information and investigations have determined that the proposed project plan will not result in adverse impacts to any federally-listed threatened or endangered species. The USFWS will be requested to concur in this determination.

Magnuson-Stevens Fishery Conservation and Management Act (Public Law 104-297). The proposed activity is outside the limits of essential fish habitat according to the NMFS. The project will not result in adverse impacts to areas considered essential fish habitat.

National Historic Preservation Act of 1966, as amended. The effect of proposed actions on historic properties has been taken into account as required by Section 106 of the Act. The Greens Bayou Flood Damage Reduction Project is covered by a Memorandum of Agreement (MOA) executed for the Buffalo Bayou and Tributaries Project in 1980. The proposed activity was coordinated with the Texas SHPO. The SHPO has concurred with the USACE determination that no historic properties will be affected (Appendix C).

Clean Water Act (CWA), as amended. Section 404 of the CWA regulates the discharge of dredged or fill material into waters of the United States. A Section 404(b)(1) evaluation of the proposed activity was prepared and is included in Appendix B. A Section 401 State Water Quality Certification for this action will be obtained to comply with the Act. The proposed plan will include Section 402(p) requirements of the CWA where applicable.

Federal Water Project Recreation Act, as amended. Consideration has been given to opportunities for recreational development afforded by the proposed plan. Recreation opportunities in the area and proposed recreational development have been included in the project authorization and are discussed in the GRR and EA. Harris County Precinct 4 has indicated an interest in serving as a local sponsor for recreation facilities associated with the project. The project lands may be used by local interests for recreational purposes.

Clean Air Act (CAA). The project is consistent with the Clean Air Act, EPA's General Conformity Rule. A preliminary analysis of air contaminant emissions for the Greens Bayou Project was done to determine if the construction of the proposed plan would generate nitrogen oxide (NO_x) and volatile organic compound (VOC) emissions (ozone precursors) above de minimus levels specified in the General Conformity rules, as established by the Clean Air Act, for the Houston Galveston Nonattainment Area (HGA) (PBS&J, 2005). Currently, the HGA is classified as a severe nonattainment area for ozone under the 1-hour National Ambient Air Quality Standard for ozone. However, the U.S. Environmental Protection Agency has recently promulgated an 8-hour ozone standard to replace the 1-hour standard. Based on the 8-hr ozone standard, the HGA will be reclassified to a moderate nonattainment area effective June 15, 2005. Accordingly, for this moderate classification, a General Conformity Analysis would not be required if NO_x or VOC emissions would be below 100 tons per year (tpy) for either NO_x or VOC. The project is scheduled to begin production in November 2005. Therefore, de minimus level used are 100 tpy each for NO_x and VOC. The results of the analysis are shown in Table 26.

Coastal Zone Management Act, as amended. The proposed activity is not included within the coastal boundary of the Texas Coastal Management Program (TCMP).

Executive Order (EO) 11990, Protection of Wetlands. The proposed project may result in impacts to jurisdictional wetlands in the proposed detention basin site. Any expected adverse impacts from construction will be mitigated. The environmental features associated with the proposed project plan include development of wetland areas in the proposed detention basin.

EO 11988, Floodplain Management. This EO directs Federal agencies to evaluate the potential effects of proposed actions in floodplains. The activities associated with construction of the recommended project must be located in the floodplain to fulfill the project's basic purpose. The proposed activity will not induce increased flooding in developed areas and will reduce future flood damages.

EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. This EO directs Federal agencies to achieve environmental justice by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies and activities on minority and low income populations. The proposed project will not have disproportionate adverse human health or environmental impacts on minority or low-income population groups within the project area.

EO 13045, Protection of Children from Environmental Health Risks and Safety Risks. This EO requires that Federal agencies identify and address environmental health and safety risks that may disproportionately affect children as a result of Federal policies, programs, and activities. The recommended project will not disproportionately impact the health or safety of children.

CEQ Memorandum, Prime or Unique Farmlands. The Farmland Protection Policy Act establishes a policy to minimize the extent to which federal programs contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses. The proposed activity will not impact any lands considered prime or unique farmlands.

Wild and Scenic Rivers. There are no rivers or river segments listed on the U.S. Department of Interior's National Inventory of River Segments in the National Wild and Scenic River System in the vicinity of the project.

8.4 REPORT RECIPIENTS

The draft general reevaluation report and environmental assessment will be circulated to interested Federal, State and local agencies, organizations, and interested groups and citizens for review. A notice of availability of the document will be sent to concerned agencies, organizations, and members of the public known to have an interest in the project.

8.5 PUBLIC VIEWS AND RESPONSES

A complete list of public comments and responses will be added to the Draft GRR/EA.

9.0 RECOMMENDATIONS

The economic evaluation of the flood damage reduction measures was based on October 2001 price levels, a 50-year period of analysis, and 5.625 percent interest rate. Uncertainties associated with the probabilities for the alternative plans are contained in the Economic Appendix. Economic costs are comprised of project implementation costs including PED costs; construction costs including operation and maintenance costs, and interest during construction (IDC). The IDC is calculated on the PED study cost, implementation costs as they occur, and land as it is consumed for the project.

Based on the EA, it is concluded that the proposed recommended plan will adversely impact approximately 14 acres of wetlands. Mitigation plans will be put into place to alleviate impacts. Factors considered are effects on vegetation, and wetlands, wildlife, aquatic resources, threatened and endangered species, water quality, historic properties, HTRW, air quality and noise, recreation, prime and unique farmlands, socioeconomic resources, environmental justice, and cumulative impacts. After careful consideration of the alternatives, the proposed plan is economically feasible, environmentally acceptable and in the public interest. A Finding of No Significant Impact (FONSI) will be prepared and signed for this action.

It is recommended that the Recommended Plan be approved for implementation as a Federal project, with such modifications thereof as in the discretion of the Commander, USACE may be advisable. The estimated first cost of the Recommended Plan, shown in Table 27, is \$37,778,000. The Federal portion of the estimated first cost is \$28,314,000; the non-Federal portion is estimated at \$9,464,000. Table 27 has been updated to show October 2004 price levels and 5.375 percent interest rate. The Non-Federal Sponsor shall, prior to implementation, agree to perform the following items of local cooperation:

a. The Non-Federal Sponsor must provide all LERRD not contaminated by hazardous, radioactive and toxic wastes, and a minimum cash contribution of 5% of the total project cost of the structural flood damage reduction features paid during construction. If the value of the contributions is less than 25% of the total project cost, the Non-Federal Sponsor must provide additional cash contribution paid during construction so that the total Non-Federal share equals 25% of the total project cost. The maximum Non-Federal contribution will not exceed 50% of the total project cost (5% cash plus 45% credit for LERRD). Arrangements for funding LERRD requirements that may exceed 45% of total project cost are covered in the PCA. The Non-Federal Sponsor must pay 100% of operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) costs and hold and save the U.S. free from damages due to the construction, operation and maintenance.

(1) Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project;

Table 27			
Project Costs			
	Item Description	MCACES (1 Oct 01 Price Level)	MCACES (1 Oct 04 Price Level)
Federal Flood Control Cost			
	Charges through 30 Nov 2003	\$ 5,230,000	\$ 5,230,000
	GRR	240,000	240,000
	Lands & Damages	39,000	42,000
	Channels & Canals	5,027,000	5,422,000
	Flood Control & Diver Str	13,071,000	13,755,000
	Engineering & Design	1,565,000	1,758,000
	Constrct Mngt	5,031,000	5,977,000
	Federal Flood Control	\$ 30,203,000	\$ 32,424,000
Non-Federal Flood Control Cost			
	Lands & Damages	\$ 6,945,000	\$ 7,333,000
	Relocations	630,000	691,000
	Non-Federal Flood Control	\$ 7,575,000	\$ 8,024,000
	Total Flood Control	\$ 37,778,000	\$ 40,448,000
Cost Apportionment Flood Control			
	Federal Flood Control	\$ 30,203,000	\$ 32,424,000
	Less Non-Federal 5% Cash Contribution	1,889,000	2,022,000
	TOTAL FEDERAL FLOOD CONTROL	\$ 28,314,000	\$ 30,402,000
	Non-Federal Flood Control	\$ 7,575,000	\$ 8,024,000
	Non-Federal 5% Cash Contribution	1,889,000	2,022,000
	TOTAL NON-FEDERAL FLOOD CONTROL	\$ 9,464,000	\$ 10,046,000
	TOTAL FLOOD CONTROL	\$ 37,778,000	\$ 40,448,000
	Interest During Construction	\$ 3,814,000	
	Operations and Maintenance (50-years)	\$ 4,710,000	
	(Present Worth of \$ 289,300 Annual Cost)		
	TOTAL COST	\$ 46,302,000	

(2) Provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project; and

b. Assume responsibility of OMRR&R the project or completed functional portions of the project, including mitigation features without cost to the Government, in a manner compatible with the project's authorized purpose and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

c. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of WRDA 86, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the Non-Federal Sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

d. Hold and save the Government free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors.

e. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs.

f. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the Non-Federal Sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

g. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Government determines necessary for the construction, operation, or maintenance of the project.

h. Agree that, as between the Federal Government and the Non-Federal Sponsor, the Non-Federal Sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and, to the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

i. Prescribe and enforce regulations to prevent obstruction of or encroachment on the project that would reduce the level of protection it affords or that would hinder operation or maintenance of the project.

j. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and ROW, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

k. Comply with all applicable Federal and State laws and regulations, including Section 601 of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army," and Section 402 of WRDA 1986, as amended (33 U.S.C. 701b-12), requiring non-Federal preparation and implementation of floodplain management plans.

l. Provide the Non-Federal cost share of that portion of total cultural resource preservation mitigation and data recovery costs attributable to structural and nonstructural flood control that are in excess of one percent of the total amount authorized to be appropriated for structural and nonstructural flood damage reduction.

m. Inform affected interests, at least annually, regarding the limitations of the protection afforded by the project.

n. Publicize floodplain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the floodplain and in adopting such regulations as may be necessary to ensure compatibility between future development and protection levels provided by the project. Non-Federal Sponsor should implement a Flood Plain Management Plan to implement measures, practices, and policies to reduce loss of life, injuries, damages to property and facilities, public expenditures, and other adverse impacts associated with flooding, and to preserve and enhance natural flood plain values and should also address measures which will help preserve levels of protection provided by the USACE flood damage reduction project.

o. Do not use Federal funds to meet the Non-Federal Sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

p. Agree that any part of the project identified as approved for proposed advanced work for credit under Section 104 of Public Law 99-662 must be compatible with recommended flood control project, and that any credit granted shall not relieve the Non-Federal Sponsor of its requirement to pay, in cash, 5 percent of total project costs allocated to structural flood control.

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for implementation funding. However, prior to transmittal to the Congress, the sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Colonel, USACE of Engineers
District Engineer

10. LIST OF REFERENCES

- Gadus, E. F and and S.W. Moss. 1998. Cultural Resources Survey of Eight Channel Segments and a Proposed Detention Basin on Upper Greens Bayou, Harris County, Texas. Technical Report, No.34, Prewitt and Associates, Inc. Austin, Texas.
- Gould. F.W. 1975. Texas Plants--Checklist and Ecological Summary. Texas Agricultural Experiment Station, Texas A&M University, College Station, Texas.
- Gulf Engineers and Consultants (GEC), 2003, Social Impact Analysis, Greens Bayou, Texas, Flood Control. Prepared for the Galveston District, Corps of Engineers, Contract No. DACW64-99-D-0009. 0033.
- Houston-Galveston Area Council (H-GAC) in cooperation with the Texas Natural Resource Conservation Commission, 1996. Regional Assessment of Water Quality, The Clean Rivers Program. Houston, Texas.
- H-GAC, 2004. Greens Bayou Intensive Survey and Waste Evaluation. Houston, Texas.
[http: /www.h-gac.com](http://www.h-gac.com).
- Howard, M.A., M.D. Freeman, and C.B Bowsman. 1991. Archeological Reconnaissance on Upper Greens Bayou, Harris County. Reports of Investigations No. 83. Prewitt and Associates, Inc., Austin, Texas.
- Moore, Roger G. 1991. Cultural Resources Survey of the Proposed Cutten Road Regional Detention Basin Tract, Houston, Harris County, Texas. Report of Investigations No. 52. Moore Archeological Consulting, Houston, Texas.
- PBS&J. 2005. Preliminary Air Conformity Analysis for Greens Bayou. Prepared for the Galveston District, Corps of Engineers, Contract No. W912HY-05-0001. 0004.
- Prikryl, Daniel J. and Roger G. Moore. 1997. An Archeological Survey of the Proposed Cutten Road Detention Basin Expansion Project, Northern Harris County, Texas. Report of Investigations No. 193. Moore Archeological Consulting, Houston.
- Stokes, Janelle. 1999. Research and Historic Properties Reconnaissance Survey Proposed Placement Areas, Upper Greens Bayou, Harris County, Texas. Galveston District, Corps of Engineers. Letter report to Texas Historical Commission, dated December 9, 1999.
- Texas Natural Resource Conservation Commission (TNRCC). 1996. State of Texas Water Quality Inventory. 13th Edition, Volumes 1-4. Austin, Texas.
- TNRCC. 1997. Air Quality in Texas. Austin, Texas.
- Texas Parks & Wildlife Department. 2002. Annotated County Lists of Rare Species, Harris County, Texas. Austin, Texas.

- U.S. Army, Corps of Engineers (CE). 1945. Aldine Quadrangle, Harris County, Texas, 7 ½ minute series, Scale 1:31680, 5 foot contour interval.
- CE. 1988. Feasibility Report and Final Environmental Impact Statement, Buffalo Bayou and Tributaries, Texas. Flood Damage Reduction. U.S. Army Engineer District, Galveston, Texas.
- CE. 1993. Greens Bayou, Houston, Texas. Local Urban Flood Protection Project. Initial Assessment HTRW. U.S. Army Corps of Engineers, Tulsa District. 35pp.
- CE. 1995. Limited Reevaluation Report on Separable Element Analysis, Brays Bayou at Houston, Texas. U.S. Army Engineer District, Galveston, Texas.
- U.S. Environmental Protection Agency (USEPA). 1974. Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety. Publication No. 550/0-74-004. Washington, D.C. March 1974
- USEPA. 1978. Title Protective Noise Levels, Condensed Version of EPA Levels Document, Office of Noise Abatement and Control.
- United States Geological Survey. 1919. Aldine Quadrangle, Harris County, Texas, Scale 1: 31680, 1 foot contour interval.
- Wheeler, F.F. 1976. U.S. Department of Agriculture. Soil Survey of Harris County, Texas. Soil Conservation Service in cooperation with Texas Agricultural Experiment Station and the Harris County Flood Control District.

APPENDIX A

CLEAN WATER ACT SECTION 404(b)(1) EVALUATION

**EVALUATION OF SECTION 404(b)(1) GUIDELINES
(SHORT FORM)**

**PROPOSED PROJECT: Buffalo Bayou and Tributaries, Texas, Greens Bayou at Houston, Texas,
Flood Damage Prevention**

	Yes	No*
1. Review of Compliance (230.10(a)-(d))		
A review of the proposed project indicates that:		
a. The placement represents the least environmentally damaging practicable alternative and, if in a special aquatic site, the activity associated with the placement must have direct access or proximity to, or be located in the aquatic ecosystem, to fulfill its basic purpose (if no, see section 2 and information gathered for EA alternative).	X	
b. The activity does not appear to:		
1) Violate applicable state water quality standards or effluent standards prohibited under Section 307 of the Clean Water Act;	X	
2) Jeopardize the existence of Federally listed endangered or threatened species or their habitat; and	X	
3) Violate requirements of any Federally designated marine sanctuary (if no, see section 2b and check responses from resource and water quality certifying agencies).	X	
c. The activity will not cause or contribute to significant degradation of waters of the U.S. including adverse effects on human health, life stages of organisms dependent on the aquatic ecosystem, ecosystem diversity, productivity and stability, and recreational, aesthetic, an economic values (if no, see values, Section 2)	X	
d. Appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem (if no, see Section 5)	X	

	Not Applicable	Not Significant	Significant*
2. Technical Evaluation Factors (Subparts C-F) (where a 'Significant' category is checked, add explanation below.)			
a. Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C)			
1) Substrate impacts		X	
2) Suspended particulates/turbidity impacts		X	
3) Water column impacts		X	
4) Alteration of current patterns and water circulation	X		
5) Alteration of normal water fluctuation/hydroperiod	X		
6) Alteration of salinity gradients	X		
b. Biological Characteristics of the Aquatic Ecosystem (Subpart D)			
1) Effect on threatened/endangered species and their habitat		X	
2) Effect on the aquatic food web		X	
3) Effect on other wildlife (mammals, birds, reptiles and amphibians)		X	

	Not Applicable	Not Significant	Significant*
2. Technical Evaluation Factors (Subparts C-F) (where a 'Significant' category is checked, add explanation below.)			
c. Special Aquatic Sites (Subpart E)			
1) Sanctuaries and refuges	X		
2) Wetlands		X	
3) Mud flats	X		
4) Vegetated shallows	X		
5) Coral reefs	X		
6) Riffle and pool complexes	X		
d. Human Use Characteristics (Subpart F)			
1) Effects on municipal and private water supplies		X	
2) Recreational and Commercial fisheries impacts		X	
3) Effects on water-related recreation		X	
4) Aesthetic impacts		X	
5) Effects on parks, national and historical monuments, national seashores, wilderness areas, research sites, and similar preserves	X		

Actions taken: Mitigation for impacts to 14.72 acres of wetlands includes the creation of 4.2 acres of wetlands within the Greens Bayou channel and 12.1 acres of wetlands within the detention basin cells for a total of 16.3 acres of wetland mitigation.

	Yes
3. Evaluation of Dredged or Fill Material (Subpart G)	
a. The following information has been considered in evaluating the biological availability of possible contaminants in dredged or fill material (check only those appropriate)	
1) Physical characteristics	X
2) Hydrography in relation to known or anticipated sources of contaminants	X
3) Results from previous testing of the material or similar material in the vicinity of the project	
4) Known, significant sources of persistent pesticides from land runoff or percolation	
5) Spill records for petroleum products or designated (Section 311 of Clean Water Act) hazardous substances	
6) Other public records of significant introduction of contaminants from industries, municipalities or other sources	
7) Known existence of substantial material deposits of substances which could be released in harmful quantities to the aquatic environment by man-induced discharge activities	
8) Other sources. Agency databases reviewed for potential sites of concern in and adjacent to the project area for the project HTRW survey	X

List appropriate references:

- 1) U.S Army Corps of Engineers (USACE). 1993. Greens Bayou, Houston, Texas, Local Urban Flood Protection Project. Initial Assessment Hazardous, Toxic, and Radioactive Wastes. USACE, Tulsa District.
- 2) Unpublished Corps of Engineer HTRW data, Greens Bayou, Texas, 1999.

	Yes	No
b. An evaluation of the appropriate information in 3a above indicates that there is reason to believe the proposed dredge or fill material is not a carrier of contaminants, or that levels of contaminants are substantively similar at extraction and placement sites and not likely to degrade the placement sites, or the material meets the testing exclusion criteria.	X	

	Yes
4. Placement Site Delineation (230.11(f))	
a. The following factors as appropriate, have been considered in evaluating the placement site:	N/A
1) Depth of water at placement site	
2) Current velocity, direction, and variability at placement site	
3) Degree of turbulence	
4) Water column stratification	
5) Discharge vessel speed and direction	
6) Rate of discharge	
7) Fill material characteristics (constituents, amount, and type of material, settling velocities)	
8) Number of discharges per unit of time	
9) Other factors affecting rates and patterns of mixing (specify)	

	Yes	No
b. An evaluation of the appropriate factors in 4a above indicates that the placement site and/or size of mixing zone are acceptable.	N/A	

	Yes	No
5. Actions to Minimize Adverse Effects (Subpart H)		
All appropriate and practicable steps have been taken, through application of recommendations of 230.70-230.77 to ensure minimal adverse effects of the proposed discharge.	X	

List actions taken:

- 1) Appropriate measures taken to minimize potential adverse impacts on the aquatic ecosystem include selection of upland placement sites, use of land-based mechanical equipment for excavation and movement of material to the placement sites, and implementation of erosion control measures. The magnitude of streambed modifications would be minimized by construction and use of a detention basin.

	Yes	No*
6. Factual Determination (230.11)		
A review of appropriate information as identified in items 2-5 above indicates that there is minimal potential for short- or long-term environmental effects of the proposed discharge as related to:		

a. Physical substrate at the placement site (review Sections 2a. 3, 4, and 5 above)	X	
b. Water circulation, fluctuation and salinity (review Sections 2a. 3, 4, and 5)	X	
c. Suspended particulates/turbidity (review Sections 2a. 3, 4, and 5)	X	
d. Contaminant availability (review Sections 2a. 3, and 4)	X	
e. Aquatic ecosystem structure and function (review Sections 2b and c, 3, and 5)	X	
f. Placement site (review Sections 2, 4, and 5)	X	
g. Cumulative impacts on the aquatic ecosystem	X	
h. Secondary impacts on the aquatic ecosystem		

7. Evaluation Responsibility

a. This evaluation was prepared by:	Kristy Morten
Position:	Environmental Specialist

8. Findings

a. The proposed placement site for discharge of or fill material complies with the Section 404(b)(1) Guidelines.	X
b. The proposed placement site for discharge of dredged or fill material complies with the Section 404(b)(1) Guidelines with the inclusion of the following conditions:	

List of conditions:

c. The proposed placement site for discharge of dredged or fill material does not comply with the Section 404(b)(1) Guidelines for the following reason(s):	
1) There is a less damaging practicable alternative	
2) The proposed discharge will result in significant degradation of the aquatic ecosystem	
3) The proposed discharge does not include all practicable and appropriate measures to minimize potential harm to the aquatic ecosystem	
Date	CAROLYN MURPHY Chief, Environmental Section

NOTES:

* A negative, significant, or unknown response indicates that the project may not be in compliance with the Section 404(b)(1) Guidelines.

Negative responses to three or more of the compliance criteria at the preliminary stage indicate that the proposed project may not be evaluated using this “short form” procedure. Care should be used in assessing pertinent portions of the technical information of items 2a-e before completing the final review of compliance.

Negative response to one of the compliance criteria at the final stage indicates that the proposed project does not comply with the Guidelines. If the economics of navigation and anchorage of Section 404(b)(2) are to be evaluated in the decision-making process, the “short form” evaluation process is inappropriate.

APPENDIX B

COORDINATION WITH OTHERS

APPENDIX C

HEP EVALUATION AND CE/ICA FOR PROJECT MITIGATION

APPENDIX D

ECONOMIC ANALYSIS

APPENDIX E

REAL ESTATE PLAN